

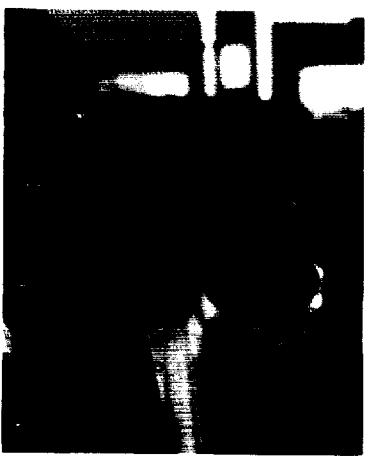
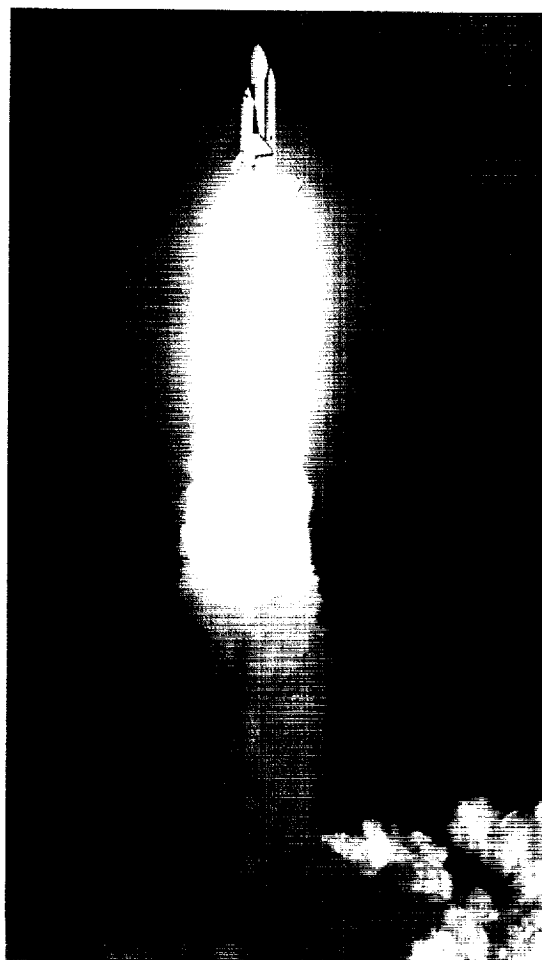
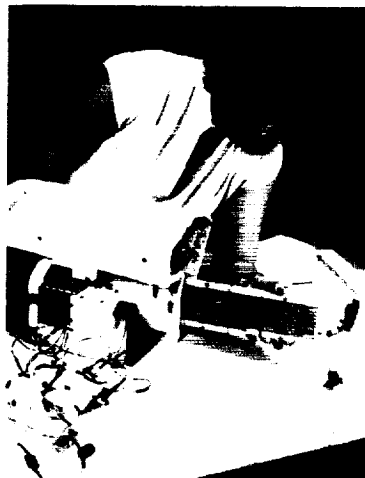


(NASA-TM-102921) GET AWAY SPECIAL: THE
FIRST TEN YEARS (NASA) 46 p CSCL 22A

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GET AWAY SPECIAL
... the first ten years



This publication is dedicated to the experimenters who created GAS payloads and to the NASA employees and contractors who helped make their dreams a reality.

FOREWORD

The National Aeronautics and Space Administration's (NASA's) Get Away Special Program has been unique in the aerospace world for the exceptional range of nonprofessional and professional experimenters who have gained access to space through it. For this reason, the program is brimming with noteworthy stories about people and their scientific endeavors. The completion of the Get Away Special Program's first ten years in 1987 posed an ideal time to compile these experiences.

This brief history begins with the origins of the Get Away Special Program in The Concept section. It continues to tell of milestones in the program's development in the STS Mission Descriptions. Perhaps most interesting, particularly to potential experimenters, are the overviews of individual customer payloads, chronologically grouped with their respective Shuttle missions. We hope this publication gives a sense of the novel opportunities that have been taken and continue to exist in the Get Away Special Program.

GET AWAY SPECIAL

. . . the first ten years

Published by
Goddard Space Flight Center, Special Payloads Division
The NASA GAS Team
1989

**ORIGINAL CONTAINS
COLOR ILLUSTRATIONS**

Contents

The Concept	3	G469 Cosmic Ray Upset II.....	24
STS-3 Flight Verification Payload	5	G518 Utah Payloads Fly Again	24
STS-4	6	STS-51-D	25
G001 The First Flight.....	7	G035 Waterball Collisions.....	25
STS-5	8	G471 Capillary Pumped Loop.....	25
G026 German Materials Processing..	8	STS-51-B	26
STS-6	9	G010 Northern Utah Satellite	27
G005 Japanese Snowflakes	9	G308 GLOMR Satellite.....	27
G049 Air Force Cadets	10	STS-51-G	28
G381 Exposing Seeds to Space.....	10	G025 Liquid Sloshing Test	28
STS-7	11	G027 Ceramic Technology	29
G002 German Students.....	12	G028 Manganese-Bismuth Alloy ..	29
G009 Purdue University Students ..	12	G034 El Paso High Schools.....	30
G012 New Jersey Students	13	G314 UV Radiation Environment ..	30
G033 Cal Tech Students	13	G471 Capillary Pumped Loop.....	30
G088 Soldering in Space.....	14	STS-61-A	31
G305 Space UV Radiation Test.....	14	G308 GLOMR's Deployment.....	31
G345 Ultraviolet Film Test	14	STS-61-B	32
STS-8	15	G479 Canadian Vapor Deposition ..	32
G346 Cosmic Ray Upset.....	16	STS-61-C	33
G347 Ultraviolet Film Test	16	EMP GAS Bridge Environment... ..	34
G348 Atomic Oxygen Test	17	G007 Radio Transmissions Test....	34
G475 Snowflakes in Space	17	G062 Penn State/GE Payload.....	34
STS-41-B	18	G310 Air Force Vibrating Beams... ..	35
G004 Space Paks	19	G332 Houston High Schools.....	35
G008 Utah Students.....	19	G446 Chemical Analysis Tests	35
G051 GTE's Metalarc Lamp.....	20	G449 Medical Laser Tests	36
G309 Cosmic Ray Upset II	20	G462,3, &4 Cosmic Background	36
G349 Atomic Oxygen Experiment ..	20	G470 Moth in Space Project	37
STS-41-G	21	G481 Transporting Art Supplies ...	37
G007 Radio Signals From Space ...	22	G494 Canadian PHOTONS Test ...	37
G013 Halogen Lamps	22	Chart of Payload Customers and	
G032 Shooting BB's at Waterballs ..	22	Representatives	38
G038 Space Art	23	Into The Next Decade	40
G074 Improving Spacecraft Fueling..	23	For More Information	40
G306 Trapped Ions in Space.....	24		



The original GAS Team was a handful of NASA engineers who conceived the program's hardware and procedures. The team members included (L to R) Clarke Prouty, Leonard Arnowitz, John Laudadio, Bob McDonnell, Dave Wing, James Barrowman, and James O'Brien.

The Concept

TO TELL the Get Away Special story is to tell more than 50 stories in one, for each payload came from the excitement, dreams, and efforts of groups of individuals. There were students who built their first space experiments; experienced scientists with projects that could lead to new materials; companies testing products for living and working in space; and others, such as artists and medical professionals, who turned their thoughts to experimentation in space for the first time. Finally, there is the story of the NASA and contractor personnel who conceived the program and worked together to make it happen.

In the mid 1970s, the Customer Services Division at NASA Headquarters in Washington, D.C. began manifesting (assigning) major payloads aboard Shuttle missions. It soon became apparent that most missions would have a small amount of capacity left after the major payloads were installed. NASA's discussions of how to best utilize this capacity led to the Small Self-Contained Payloads Program, now familiarly known as the Get Away Special Program or, simply, the GAS Program.

From its beginning, those working in the GAS Program realized that it really was a special program. It was an avenue, never before available, to space experimentation for the "man and woman on the street." In the expensive world of space exploration such an opportunity had been nonexistent. Anyone, including domestic and international organizations, could perform a small space experiment through the GAS program. It was hoped that by opening GAS to the broadest community possible, many goals of national interest would be served: encouraging the use of space by all; enhancing education with hands-

on space research opportunities; inexpensively testing ideas that could later grow into major space experiments; and, finally, generating new activities unique to space.

In October 1976, John Yardley, Associate Administrator for the Office of Space Flight at NASA Headquarters, announced the inception of the GAS Program at a convention of the International Astronautical Federation in Anaheim, California. The next day, Mr. R. Gilbert Moore purchased the first GAS payload reservation. Mr. Moore enthusiastically advocated the GAS program throughout aerospace circles, and his advocacy soon bore fruit, as others began depositing money for GAS payload reservations.

Over the next few months, NASA worked to define the program's boundaries. Only payloads of a scientific research and development nature that met NASA safety regulations would be accepted. Payloads would have to be self-contained, supplying their own power, means of data collection, and event sequencing. NASA's original concept was to fly payloads in closed containers with no external controls available. Recognizing that the technical experience of GAS customers would range widely, NASA designed a container that could contain potential hazards.

Three payload options evolved: a 2½-cubic-foot container for payloads up to 60 pounds, costing \$3000; a 2½-cubic-foot container for payloads 61 to 100 pounds for \$5000; and a 5-cubic-foot container for 200-pound payloads for \$10,000. This pricing policy was modeled after the policy for major Shuttle payloads, which are charged by payload weight and volume.



Preparing to lift a payload into the orbiter

Early in 1977, NASA assigned the GAS Program to the Sounding Rocket Division at the Goddard Space Flight Center in Greenbelt, Maryland. Later renamed the Special Payloads Division, its personnel had, at that time, accumulated twenty years of hands-on engineering experience in flying sounding rocket payloads. Their expertise was ideal for a small payloads program. A handful of engineers began meeting weekly to define the hardware and procedures necessary for the GAS Program. This was the beginning of the GAS team.

Meanwhile, news of the GAS Program had passed by word-of-mouth through the aerospace community. With no publicity since Yardley's initial announcement the previous year, over one hundred payload reservation numbers had already been issued.

IN THE TEN YEARS and 53 payloads flown since the program's inception, the GAS team has kept its enthusiasm for the program — largely because of the experimenters' high level of enthusiasm and endless ability to conceive and design thought-provoking experiments. The originators of the GAS Program could not have envisioned the innovativeness of some of the customers' payloads. As you will learn, customers' requirements for these experiments sometimes prompted the GAS team to develop

new equipment and procedures to meet their experimenters' needs.

Importantly, the GAS Program continues to meet its original goal of providing access to space to everyone. The program offers an inexpensive vehicle through which both novices and professionals can explore new concepts in space at little risk. With major payloads, a failing experiment can be catastrophic; the failure of a GAS experiment can, however, be a useful experience from which both students and scientists can learn and prepare for bigger missions in the future.

Since the program's early days, the GAS team at Goddard has relied on numerous NASA and contractor personnel at the Johnson and Kennedy Space Centers. Without their active support, GAS payloads would never have left the ground. GAS team members at Johnson helped establish simplified integration, operational, and safety documentation procedures. Personnel at Kennedy streamlined techniques and procedures for processing payloads from arrival at Kennedy to installation in the orbiters and from their postflight removal to their shipment back to the experimenters. As well, Kennedy team members found a home for the GAS Program on Cape Canaveral.

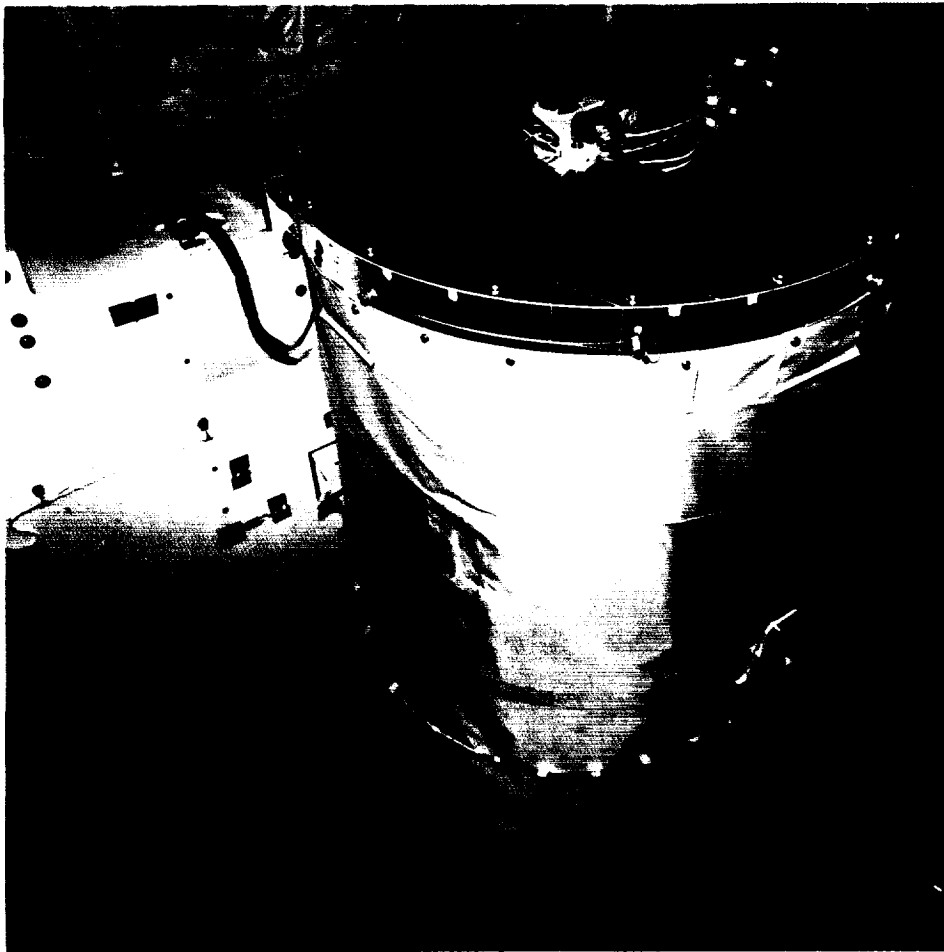
READERS INTRIGUED BY THE EXPERIMENTS in this publication will no doubt wonder about their results. An unusual feature of the GAS Program is that experimenters are not required to furnish postflight reports to NASA. NASA feels that GAS customers can best speak for their own experiments. The following payload descriptions have been compiled from preflight press releases and discussions with GAS experimenters. Generally, payload results are mentioned only when they illustrate lessons that were learned. Readers can, however, review the payloads and their results in more detail by obtaining papers presented by the experimenters at NASA's Annual Get Away Special Experimenter's Symposiums. Symposium proceedings are available from:

The National Technical Information Service
Springfield, Virginia 22161

The proceedings of each symposium are assigned a conference publication number, as listed below:

GAS Experimenter's Symposium	NASA Conference Publication No.
1984	2324
1985	2401
1986	2438
1987	2500

THE GAS TEAM HOPES this brief history of the experiments flown through January 18, 1986, illustrates both the diverse use of the GAS program and its vast possibilities. We also hope it will stimulate others to become explorers of space.



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STS-3

Columbia, March 22, 1982

BEFORE GAS CUSTOMERS COULD PREPARE realistic payload designs, they needed an accurate description of the environment inside a GAS container. Early in the program, the GAS team proposed flying a Flight Verification Payload (FVP) for this purpose. The FVP would record the vibrations, pressure, and microgravity inside a GAS container, as well as the internal and external temperature levels.

The GAS team did not anticipate flying this or any other payload until the Space Shuttle test flights (missions STS-1 through STS-4) were complete in June 1982. After the first two test flights, this situation changed. Based on the Shuttle's test performance, NASA managers and engineers grew confident that the Shuttle could handle more payloads. However, in expanding its capacity, they had to maintain the Shuttle's center of gravity in the optimum location for controllability during re-entry and landing. Considering this, Johnson Space Center mission planners realized that another 550 pounds — the approximate weight of a GAS container and its adapter (installation) beam — was needed as ballast for STS-3's aft (rear) cargo bay. Thus, the GAS Program and the FVP received an early go-ahead for the STS-3 flight in March 1982.

Although opportune, this decision posed an immediate hardware problem for the GAS team. Generally, light payloads, such as GAS containers, are to be located in the forward end of the cargo bay. Consequently, the adapter beams built for installing GAS payloads in the orbiter would not fit in the aft section.

Johnson engineers came to the rescue. They quickly fabricated a GAS adapter beam for the aft starboard (right) side of the bay. In this location the FVP (and other early GAS payloads) flew as scheduled. Following the FVP's successful flight, the GAS team distributed the test results to its existing experimenter community and later incorporated them in the *GAS Experimenter Handbook*.

Along with its environmental data, the FVP proved invaluable in an unforeseen way. For the first time, the team had to design a GAS payload and provide for its integration and installation in the Space Transportation System (STS). With Johnson and Kennedy Space Centers' personnel, the team members developed procedures for manifesting, shipping, checking, inspecting, installing, and deintegrating (postflight) the FVP. Having put the FVP through these operations, such procedures were considerably eased for future GAS customers.



Attaching the first GAS payload to its adapter beam in the Columbia cargo bay

STS-4

Columbia, June 27, 1982

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WHEN PREPARING THE FIRST CUSTOMER payloads for flight, the GAS team ran into an unexpected difficulty: clearly understanding the customers' payload needs (for example, length of operation, control commands, safety requirements). Numerous discussions with their first customer, the Utah State University (USU) group, culminated with USU's submission of two inch-thick documents concerning their payload. Obviously, a more efficient way of getting payload specifications was needed.

Ironically, the team's problem stemmed from one of the GAS program's strongest points — that it brought new people into space exploration. Having never dealt with inexperienced space experimenters, the team members soon found they could not expect the same level of knowledge about space or NASA requirements as they assumed from seasoned experimenters. The team's experiences with USU and its other early customers enabled it to

develop a questionnaire entitled the *Payload Accommodations Requirements* (PAR). Still in use, this document — much shorter than the material submitted by USU — asks specific questions that help everyone understand a payload's flight requirements.

The actual leg-work involved in attaching the first payload in the orbiter's payload bay began three months prior to launch, when the USU group put payload G001 in a private plane and headed for Kennedy Space Center. Once there, the GAS team and USU crew carried out preflight preparations: inspecting G001 for post-shipment damage, installing its batteries, running a final preflight check on the experiments, and integrating G001 into the flight container. Next, a truck delivered the payload to the orbiter, and while Kennedy personnel installed it, the GAS team and a USU representative witnessed the process and stood by for consultation. After final electrical interface checks in the orbiter, installation was complete. Having

run smoothly, this process became standard for all following GAS flights.

As STS-4 roared into the sky above Kennedy on June 27, 1982, USU students, faculty, and their supporters cheered their experiments into space. However, during their celebration later that night, they learned that NASA could not turn on their payload. Back at Goddard, GAS engineers were already assessing the problem. After intensive study, they concluded that one of the wires connecting

the payload controller in the crew compartment to the GAS container was broken. Working closely with Johnson Space Center, the engineers devised a procedure to re-route the connection in orbit. Johnson sent instructions to Columbia's crew; they made the new connection, and the payload was turned on. This unexpected, but exciting, beginning for the GAS Program illustrated that having people in space to perform operations is vital when problems arise.

PAYLOAD: G001
CUSTOMER: R. Gilbert Moore

***The Maiden Voyage:** When R. Gilbert Moore, a Martin Thiokol Corporation executive, donated the first GAS payload to Utah State University (USU), he presented USU students with a new world of hands-on space research. From this first payload a scholarship program emerged in which undergraduate students could design and build experiments to be flown in GAS payloads. Students have since generated four payloads, totalling 22 experiments, while assisting other universities and institutions with their GAS projects.*

USU's first payload was very ambitious. Students put ten experiments into a 5-cubic-foot GAS container. One experiment grew successive generations of fruit flies to see if microgravity would affect their genetic structure. Other tests examined the effects of microgravity on epoxy resin-graphite composite curing, brine shrimp genetics, duckweed root growth, soldering, homogeneous alloy formation, surface tension, growth rate of algae, and thermal conductivity of a water and oil mixture. A student's master degree thesis surveyed the distribution of temperature within the payload. Perhaps the biggest challenge went to the graduate student who integrated all the experiments into the payload — locating and scheduling their operations so that power and thermal requirements would not conflict.



The day after the GAS Program was announced, Gilbert Moore (center) made the first reservation with Chet Lee, Director of Customer Services, and Donna Miller, GAS Program Manager.



The G001 team: (L to R, kneeling) sponsors Gilbert Moore and Phyllis Moore; USU Professor Rex Megill; (standing) Thiokol Corporation advisor Donald Cook; students Amber Dalley, Russ Laher, Terrance Thomas, David Yoel, James Elwell, Bruce Moore, Walt Moore, Steven Walker, and Kelly Hunt; Thiokol advisors Lynn Hankins and Gladyce O'Dell.

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STS-5

Columbia, November 11, 1982

WITH FOUR TEST FLIGHTS under its wings, the orbiter opened its cargo bay to commercial customers. Aboard was the first GAS payload owned by an international customer, the German Aerospace Research Establishment (DFVLR). DFVLR was also first of many sophisticated organizations to seize the opportunity offered by the GAS Program to perform microgravity materials processing research at relatively low cost. Such research aims to create perfect crystals, high-strength metals and alloys, and new chemicals for uses as varied as communications systems, spacecraft materials, and medicine.

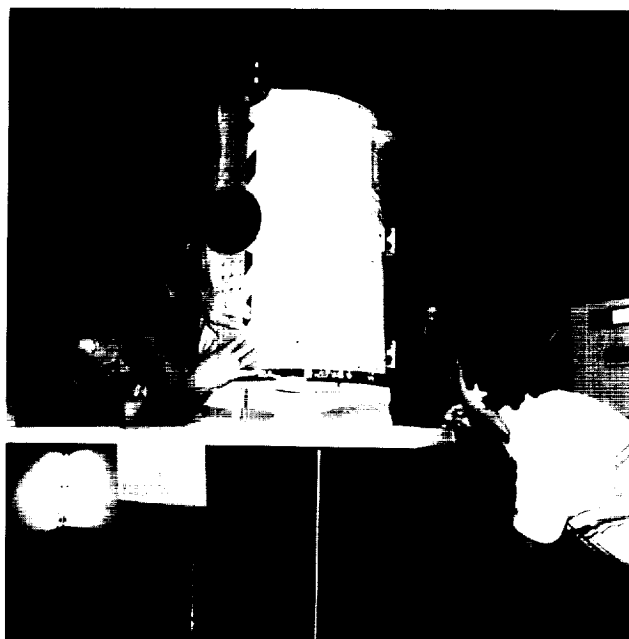
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Postflight: the GAS team rushes a payload from the orbiter to the GAS facility where experimenters can see the payload's results.

PAYLOAD: G026
CUSTOMER: DFVLR, The German Aerospace Research Establishment; H. Schreiber, H. Hebenstrick

First in a series of 25 GAS payloads managed by the German Aerospace Research Establishment (DFVLR), G026 was part of the German material science program called Project MAUS. German scientists anticipated an increased understanding of the preparation of dispersion alloys in space from G026. They were working with the knowledge that several combinations of two different metals can be dissolved together in their liquid state above a certain temperature (consolute temperature), but cannot be mixed below this temperature. They used such a combination of gallium and mercury in G026 to investigate the dissolution process above the consolute temperature, as well as the time-dependent stability of the resulting dispersion, composed of mercury droplets in gallium. For the first time, X-ray recordings were to be used to provide real-time data of the different states of the experiment sequence. Previously, dispersions could not be observed as they occurred and, instead, clues to the process had to be sought when the solidified samples were returned to Earth.

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X-ray technology would make the first recordings of dispersion alloys forming in space on G026. Preparing the payload: (L to R) Gary Walters, GAS Field Operations Manager, and German scientists Dr. Gunter Otto and Dr. Peter Vits.

STS-6

Challenger, April 4, 1983

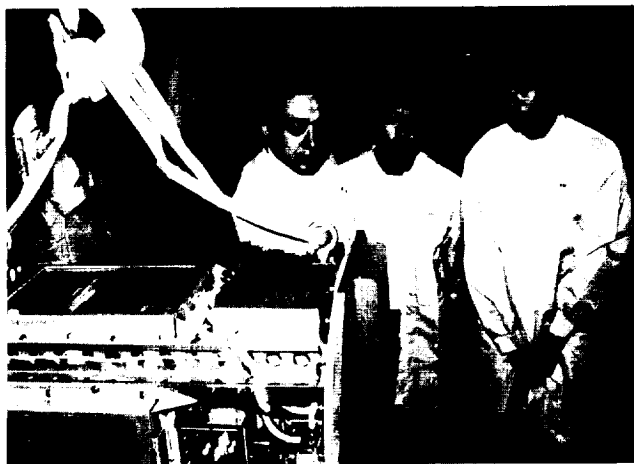
THE GAS TEAM FACED an unusual and unexpected challenge during preflight preparations of STS-6. The Challenger was at the launch pad with the GAS payloads already installed, when problems with the major payload, the Tracking and Data Relay Satellite, (TDRS), delayed the Shuttle's launch. The GAS team grew concerned that in the interim before launch the batteries in GAS payload G005 would drain.

Normally, the GAS team would not have access to the orbiter after GAS payloads have been installed. On this occasion, however, the Kennedy Space Center personnel were working on the TDRS away from the launch pad. This left the cargo bay empty — and created a unique opportunity for the GAS team.

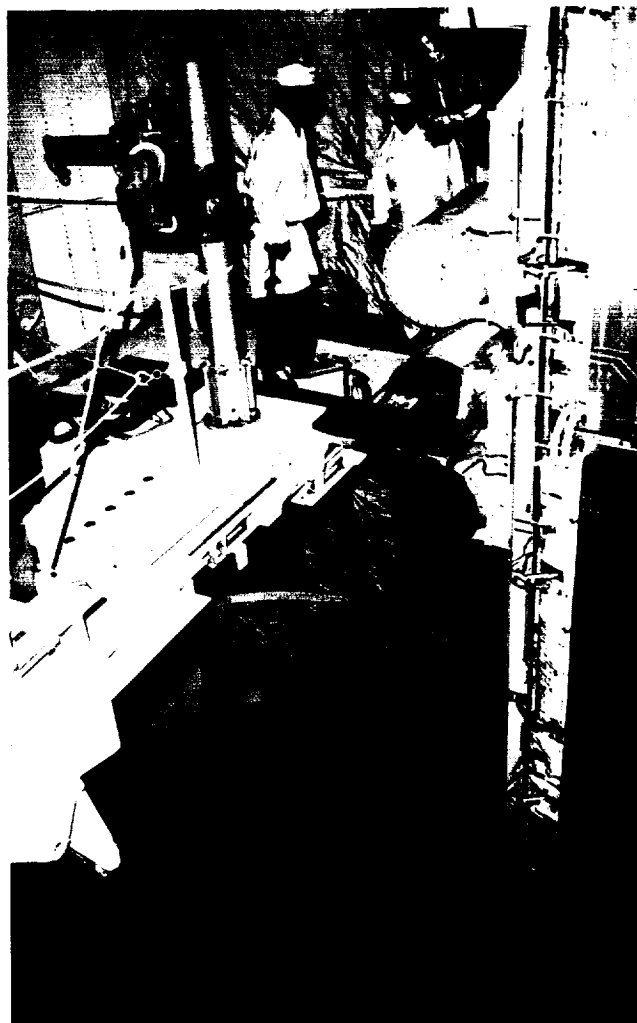
The team contacted experimenter Shigeru Kimura in Tokyo to learn if he wanted his payload removed from the Challenger so that the batteries could be recharged. Kimura's response was immediate: his crew flew from Japan and joined the team at Kennedy for the job.

After Kennedy's personnel and contractors removed G005 from the cargo bay, the payload was delivered to the GAS team and Kimura's crew at the GAS preparation facility. The two teams removed the experiment from the container, took out its batteries and charged and re-installed them. Then, once again, they ran a full preflight check and returned G005 to the orbiter, ready for flight.

Two "firsts" for the GAS program also marked this mission. STS-6 gave the GAS Program the first opportunity to fly more than one payload. Of the three flown, payload G381, built by the George W. Park Seed Company, went from concept to installation in about 90 days. This record time was accomplished by a company with no previous experience in space experimentation — proof that the GAS Program could, indeed, provide experimenters rapid access to space.



(L to R) The late Shigeru Kimura, Asahi Shimbun's payload manager, with the students who suggested making snowflakes in space, Toshio Agawa and Haruhiko Oda.



In an unusual procedure, GAS team members removed G005 from the forward end of the cargo bay to recharge its batteries.

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PAYLOAD: G005
CUSTOMER: The Asahi Shimbun;
Shigeru Kimura

Over 17,000 ideas from Japanese scientists, university professors, engineers, and students flooded Tokyo's Asahi Shimbun newspaper after it solicited themes for a GAS payload. The winning entry came from two high school boys. Their suggestion? Making snow in microgravity. Since a Japanese physicist had produced the first artificial snow on Earth, it seemed appropriate to newspaper editor Shigeru Kimura that Japan crystallize the first artificial snow in space. Executing this task in the small volume of a GAS container required the collaboration of engineering and scientific experts. Before flight, scientists could only guess what shape flakes would take in the absence of gravity — possibly symmetrical, maybe even spherical. The answer, to be observed and recorded by home video equipment, would contribute data on the growth of semiconductor crystals and other materials from vapor sources in space.

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U.S. Air Force Academy cadets prepare G049 for flight.

PAYLOAD: G049
CUSTOMER: U.S. Air Force Academy;
 General Robert E. Kelley

Air Force academy cadets in Colorado Springs designed research and development projects for the Shuttle and then marketed them to their instructor in a program management course based around the Academy's first GAS container. The cadets behind two of the experiments in G049 were looking to the day when structures would be built in space. One such experiment on metal beam joining demonstrated that beams could be soldered in space. Another on foamed metal (a metal in which a significant amount of gas bubbles are suspended) took a dense piece of metal and foamed it into a rigid metallic sponge. This technique could someday be used to produce structural rods and bars in space, thus reducing the cost of shipping building materials into space. The cadets' other experiments explored microorganism development, metal alloys, electroplating, and metal purification. All in all, over 450 cadets were exposed to space science through this single GAS payload.

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PAYLOAD: G381
CUSTOMER: George W. Park Seed Co.;
 George B. Park, Jr.

A man with a vision, George B. Park, Jr. realized that future space station inhabitants may need to grow their own food. As vice president of the George W. Park Seed Company, Park wanted to learn how to package seeds for space shipment. His researchers packed 25 pounds of fruit and vegetable seeds into G381, some in simple dacron bags, others in sealed plastic pouches. Within the container were two compartments — one holding the Earth's atmosphere, the other vented to the cargo bay. The seeds in the vented compartment were exposed to the vacuum, severe temperatures, and radiation of space. After returning to Earth, the seeds would be grown and compared to two control groups that had remained on Earth. The outcomes of this payload convinced the Seed Company to fly a more advanced seed experiment in the Long Duration Exposure Facility, placed in orbit by the Shuttle in 1984.



Anticipation (L to R): Dr. James Alston opens the Park Seed Co. payload, as other GAS customers and GAS team member Steve Grenillo watch.

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STS-7

Challenger, June 18, 1983

THE GAS TEAM'S RESOURCEFULNESS was challenged by the STS-7 mission. More GAS payloads were to fly on this mission than on all the previous flights combined. To complicate matters, during preparation of the seven payloads, the program inaugurated and set up a new GAS preparation facility at Cape Canaveral. The team soon learned that all the payloads could not be handled at once in their new building. Therefore, they also had to plan and execute a flow of work through the facility.

At the same time, a new piece of container hardware was being prepared for its first flight. Since the beginning of the program, many customers had requested the ability to fully expose their experiments to space, so in the original program policy, NASA committed itself to providing this

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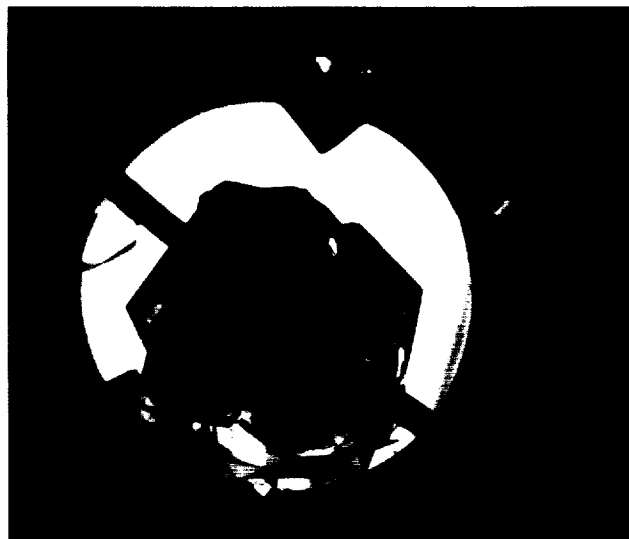
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optional service. The U.S. Air Force, having payloads that required full exposure, offered to fund the design and fabrication of a Motorized Door Assembly (MDA) if the Air Force could be the first to use it. Following their initial use of the MDA, it would belong to NASA and be available to all GAS experimenters. The first payload to use the MDA was conceived and built by the U.S. Naval Research Laboratory. Since the Laboratory is near Goddard Space Flight Center, the GAS team decided to integrate the payload with the MDA at Goddard and ship the assembled payload as a unit to the launch site.

The challenges of STS-7 drew the GAS Program forward; having met them, the GAS team knew they were ready for the heavier flight schedules ahead.

PAYLOAD: G002
CUSTOMER: Kayser-Threde GMBH;
Reiner Klett

Winners of a nationwide competition among West German High School students provided the experiments for G002. Their five experiments covered a full spectrum of science and technology with studies of crystal growth, nickel catalysts, plant contamination by heavy metals, microprocessor controlled sequencers, and a biostack studying the influence of cosmic radiation on plant seeds. The competition was organized by the nonprofit Jugend Forscht Association and funded by the German Ministry for Research and Technology. The aerospace company Kayser-Threde donated the GAS flight opportunity and helped the students build and integrate their experiments.



This crystal formed in microgravity in the German Youth Fair Science Organization's payload.

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Purdue Student Gene McGinnis concentrates on G009's preparation.

PAYLOAD: G009
CUSTOMER: Purdue University

Purdue University students conducted three experiments in their payload. The first tested seed growth in microgravity in an unconventional way — by germinating seeds on a spinning disc. The degree of gravity on a spinning wheel is highest at its rim and lowest at its center. Using this fact, the students planned to chart the influence of different levels of gravity on seed germination by placing seeds at different radial locations on the disk. Their payload also included a nuclear particle detection experiment. This experiment traced and recorded the paths of nuclear particles encountered in the near-Earth space environment. A third experiment on fluid dynamics measured the bulk oscillations of a drop of mercury immersed in a clear liquid. Purdue's Schools of Science, Engineering, and Agriculture developed the flight hardware for the project, with the U.S. Navy providing access to the necessary test facilities.

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PAYLOAD: G012
CUSTOMER: RCA; David Shore

Science, art, shop, and music students took part in the five-year GAS project at Camden and Woodrow Wilson High Schools in Camden, New Jersey. Backed by their faculties and technical experts at RCA Corporation and Temple University, science students built an ant farm to learn if weightlessness would affect the colony's social structure. Behind the scenes, helpers from other classes fabricated the container housing, painted Orbit '81 murals, produced a GAS newsletter, and enacted plays for fund raisers. Although the colony perished aboard the Shuttle, learning did not stop after the flight. Biology students investigated the colony upon its return. They concluded that the ants died of dehydration when the GAS container was purged with dry air during preflight preparations. Even so, students rated their project a success: in their words, it "gave Camden students the opportunity to prove that they are as capable in the sciences as they are in sports."



Students and teachers of Camden and Woodrow Wilson High Schools work with their RCA sponsors on the ant colony experiment.

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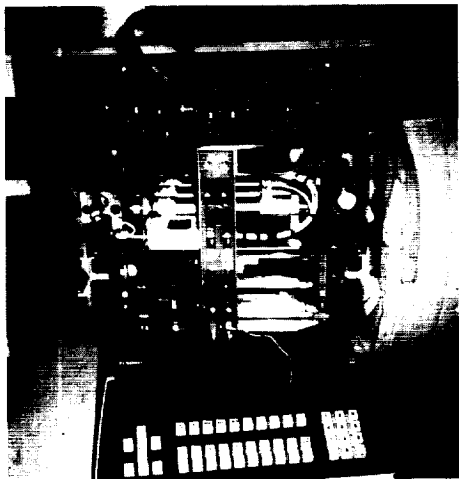
PAYLOAD: G033
CUSTOMER: Steven Spielberg

Movie director Steven Spielberg donated G033 to the California Institute of Technology after receiving the payload as a gift. Working late nights and holidays, fifteen undergraduates in Cal Tech's Student Space Organization designed and built two experiments, as well as the computer that ran and monitored their payload. One experiment examined oil and water separation in microgravity. The second experiment grew radish seeds, testing the theory that roots grow downward because gravity forces dense structures (amyloplasts) to settle to the bottom of root cells.



The seven GAS payloads on STS-7 were photographed from the German Shuttle Pallet Satellite (STS's major payload). The German payload was flying free in space after the remote manipulator system (foreground) lifted it out of the Shuttle bay.

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Over 60 soldering experiments flew in G088.

PAYLOAD: G088
CUSTOMER: Edsyn, Inc.;
 William S. Fortune

Virtually nothing was known about soldering in space when Edsyn, Inc. conceived this payload. Looking ahead to the necessity of doing maintenance and repairs in space, Edsyn ran over 60 experiments on the soldering and desoldering equipment in G088. Passive experiments determined how soldering gear, such as static/temperature meters, electronic shears, check valves, and soldering irons, would function in space. Powered experiments investigated the physics of soldering in microgravity and a vacuum. They tested the reaction of flux; measured the solder's wetting and surface tension; tested metallurgical properties; and determined how to remove solder from a printed circuit board.



Henry Fitch, University of New Mexico Physical Sciences Lab, builds the GAS program's first Motorized Door Assembly.

PAYLOAD: G305
CUSTOMER: Department of Defense Space Test Program;
 Richard B. Kehl

The Space Ultraviolet Radiation Environment (SURE) instrument, developed by the U.S. Naval Research Laboratory (NRL) Space Science Division, marked the debut of the GAS Motorized Door Assembly (MDA). The MDA made it possible for the payload's spectrometer to measure the natural radiation in the upper atmosphere at extreme ultraviolet wavelengths. SURE was first in a series of experiments planned by the NRL which ultimately would have the capability of providing global pictures of "ionospheric weather." This capability is expected to provide immediate information about the effects of ionospheric storms and solar flares or eruptions on communications systems around the globe.

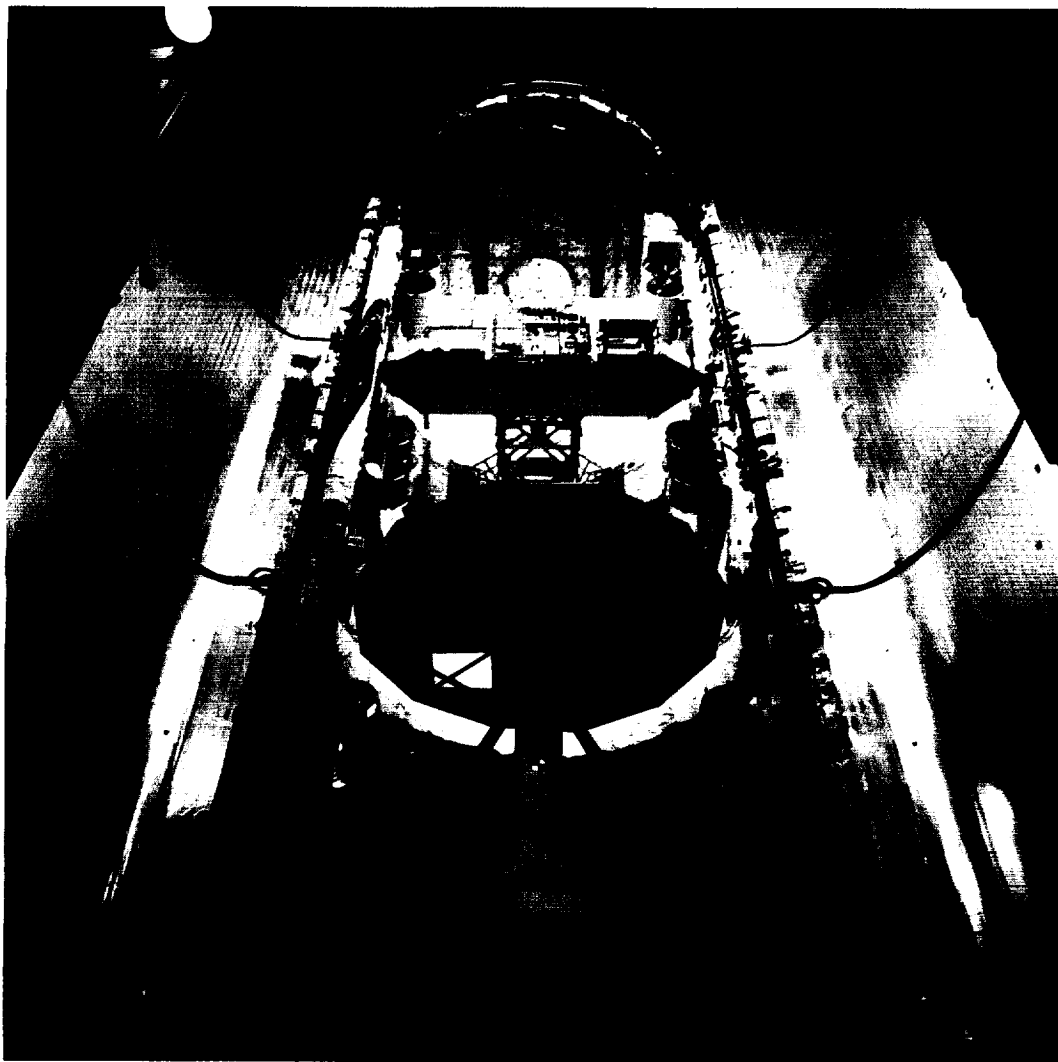


Robert Kreplin (left), U.S. Naval Research Lab, shows G345 to Clarke Prouty, GAS technical liaison.

PAYLOAD: G345
CUSTOMER: Goddard Space Flight Center;
 Noel W. Hinners

Film used in instruments such as Spacelab 2's High Resolution Telescope and Spectrograph faced a severe challenge. It had to be strong enough to withstand the effects of contaminants given off by the Shuttle propulsion system and the payloads, while sensitive enough to detect ultraviolet radiation. Prior to Spacelab 2's flight, the Naval Research Laboratory and Goddard Space Flight Center designed the Ultraviolet Photographic Test Package to expose film samples to the space environment. The experimenters evaluated the effects of Shuttle bay contaminants on these sensitive emulsions and identified possible design implications for new instruments.

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STS-8

Challenger, August 30, 1983

THE OPPORTUNITY FOR 12 GAS PAYLOADS to ride on STS-8 came on such short notice that only four customers could accept the flight offer. One of the customer groups jumped at the flight opportunity — even though their payload was only in the conceptual stage. Their reason? The unusual orbit and orientation planned for the STS-8 mission.

Because of the requirements of one of the major payloads, STS-8 was planned to fly at a lower than normal altitude in the upper atmosphere, where there are more atmospheric constituents than in higher altitude orbits. It would also have a different orientation. On most missions, the cargo bay faces the Earth's surface, making the Shuttle appear upside-down to a ground-based observer. However, during part of the STS-8 mission, the cargo bay would face into the direction of flight.

The orbit and inclination were ideal for scientists at Goddard Space Flight Center who were planning a GAS payload to monitor atomic oxygen. These oxygen atoms

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are most prevalent in the upper atmosphere, and with their experiment heading into the airflow, more atomic oxygen would collide into its sensors than normally possible.

The only part of this experiment that was somewhat prepared two months prior to flight was the Contamination Monitor Package (CMP). The CMP held the distinction of being the first experiment to be attached to the outside of a GAS container. Having been used previously as part of a major payload, the only change required on the CMP was modification of its mounting hardware so that it could be attached to the GAS container. On the other hand, the rest of the experiment, including its command package and electronics, had to be modified, integrated, and assembled. The experimenters "went all out" to complete their payload in time, even borrowing a tape recorder, battery, and interface electronics box. In 56 days their payload was ready for installation — another record time for the preparation of a GAS payload.



(L to R) CRUX I and II's technician and design engineer, George Schoppet and John Yagelowich

PAYLOAD: G346
CUSTOMER: Goddard Space Flight Center;
 Noel W. Hinners

The Cosmic Ray Upset Experiment (CRUX) in G346 was designed to study how cosmic rays — highly charged particles in space — upset microcomputer chip memory circuits. A number of flight anomalies in NASA and DOD spacecraft systems have been attributed to these cosmic ray upsets. When a single highly charged particle deposits or loses energy as it passes through a sensitive volume in a memory cell, a soft error, or change in logic state, can occur. In some technologies, a particle initiates a "latchup" condition within the bulk of the microcircuit, resulting in high-current drain by the microcircuit and catastrophic failure. Since the rate of such single event upsets increases as the scale of integration (number of transistors per chip) increases, the problem has become more important as devices have become more and more dense. The purpose of CRUX was to validate a model which could predict the upset rate of a given microcircuit type in a given orbit.



Lowering G347 into the cargo bay

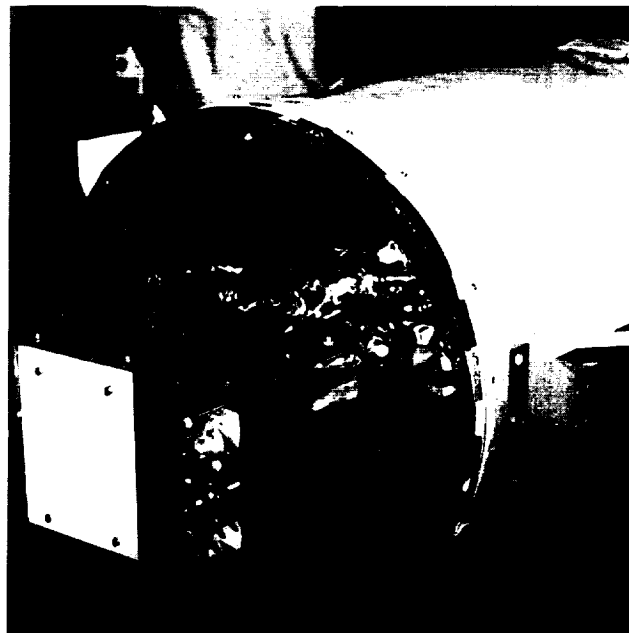
PAYLOAD: G347
CUSTOMER: Goddard Space Flight Center;
 Noel W. Hinners

Once again, the Ultraviolet Photographic Test Package (previously flown as G345 on STS-7) gathered information on how the orbiter environment affects ultraviolet (UV)-sensitive photographic emulsions. Clouds of ions that blacken UV emulsions can be produced in space through the action of solar ultraviolet radiation on a cloud of gas emanating from the payload or vehicle. If, in addition, telescope apertures face the direction of the motion of the spacecraft, ions are scooped up and rammed into the instrument's interior. There they react with photographic materials. The unusual flight attitude taken by STS-8 allowed an excellent evaluation of such an ion ram effect.

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PAYLOAD: G348
CUSTOMER: Goddard Space Flight Center;
Noel W. Hinners

On several occasions, NASA's Space Shuttles have returned from missions with their outercoatings and thermal blanket coverings dramatically changed. The white outercoating on the bay structures and fixtures came back covered with powder; the shiny gold thermal blankets on the payloads were dulled; and both coatings were significantly thinner. GAS payload G348 investigated such changes caused by atomic oxygen erosion. Present at low orbital altitudes, atomic oxygen (an oxygen atom) tears down certain materials. G348 measured the mass loss of carbon and osmium, two materials known to readily oxidize. The results were expected to provide insights for future low-orbit missions, such as the Space Station which will use a carbon-based epoxy in its construction.



The heart of the atomic oxygen test was this sensing element mounted on the GAS container lid.

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PAYLOAD: G475
CUSTOMER: The Asahi Shimbun;
Shigeru Kimura

***A successful reflight:** Seemingly simple, making the first snowflakes in space was actually a sophisticated engineering task. Data from the Asahi Shimbun's unsuccessful first attempt on STS-6 revealed that the extreme cold in space had lowered the water in their experiment to minus seven degrees Centigrade (19°F), much colder than anticipated. Consequently, the heaters could not heat the water enough to generate water vapor for snow crystals. Engineers also suspected that since there is no convection in zero gravity, the water vapor could not have spread to the field-of-view of the cameras anyway. After their evaluation, engineers tripled the power of the heaters and added a small fan, and NASA arranged to turn on the experiment as early in the mission as possible. The value of the orbiter's ability to return experiments to Earth for evaluation and modification was again demonstrated by the successful reflight of this payload.*



Video recordings showed the difference between snowflakes formed on earth (top) and those formed in space (bottom). The dark lines through the flakes are the rabbit hairs on which they formed.



The morning before launch (Photo by J.B. Edwards, Hercules, Inc.)

STS-41-B

Challenger, February 3, 1984

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JOINING JAPAN AND GERMANY as early international GAS participants, the University of Aberdeen in Scotland accepted Utah State University's (USU's) offer to share its GAS container on this mission. Smooth integration of both universities' projects into one container was enhanced by the development of "space paks."

After USU's first payload (G001) of 10 experiments, the faculty knew they needed a means of isolating experiments from each other and of fairly allotting container

space to as many students as possible. The students and faculty in USU's Get Away Special curriculum devised "space paks" — hexagonal trays that would house individual experiments. Typical of the cooperation and sharing of expertise among GAS customers, USU shared their space paks with other customers on this and subsequent missions. For USU, the space paks became a method of standardizing the space available for experiments in their GAS containers.

PAYLOAD: G004
CUSTOMER: Utah State University;
Dr. L. R. Megill

International sharing: Space science students at the University of Aberdeen in Scotland used one of the University of Utah's (USU) newly designed space paks on this payload. Aberdeen students flew experiments on spore growth, three-dimensional Brownian motion, and dimensional stability. USU students filled two other space paks in G004 with experiments that probed capillary action in the absence of the overpowering force of gravity. One of the experiments looked at capillary waves on a water surface; the other, at thermocapillary flow in columns of melted wax.



Utah students (L to R) David Prince, Sawat Tantiphawadi, and Scott Thomas proudly display their space paks (Photo by J.B. Edwards, Hercules, Inc.).

PAYLOAD: G008
CUSTOMER: Utah State University;
Dr. L. R. Megill

Two universities and a high school from Utah shared payload G008, purchased by the Utah section of the American Institute of Aeronautics and Astronautics. Three students from Brighton High School in Salt Lake City prepared a radish seed germination experiment to determine if light sources could control the direction of stem growth in the absence of gravity. A University of Utah group studied the crystallization of three different protein samples (human antibodies) in small capillary tubes. And Utah State University students redesigned a soldering experiment already flown on STS-4 and tested a heat pipe to be used in a future space experiment.



Watching the Shuttle take to space: Gilbert Moore, Thiokol Corporation, and David Prince, Brighton High School, Utah. (Photo by J.B. Edwards, Hercules, Inc.)

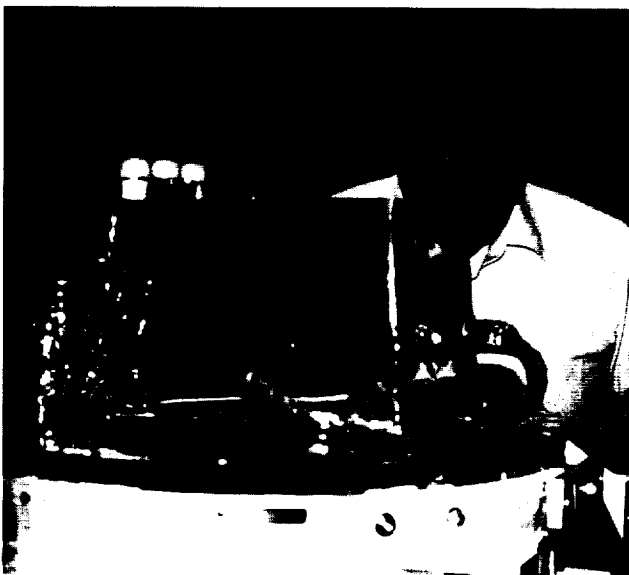
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Glen Duchene (L to R) and Alfred Bellows of GTE make final preparations of the gas-discharge lamp experiment.

PAYLOAD: G051
CUSTOMER: GTE Laboratories, Inc.

Gas-discharge lamp research: GTE Laboratories flew G051 to test the effects of microgravity on Sylvania Metalarc lamps. These high-powered gas-discharge lamps are used in industrial buildings, stadiums, and other sports facilities. On Earth, gravity-induced convection plays an important role in the separation of vapors that are mixed in the arc tube. This demixing produces changes in light output, color, and overall lamp efficiency. GTE flew its payload to see what happens inside the arc tube when the effects of gravity are separated from other influences. Three cameras were programmed to take over 700 photographs of the arc tubes and to collect data on power, temperature, and light output throughout the experiments.



Roy McIntosh preparing the Atomic Oxygen Experiment for its second flight.

PAYLOAD: G309
CUSTOMER: Department of Defense Space Test Program; Colonel John T. Viola

Since existing data on the sensitivity of microcircuits to cosmic rays in space was sparse and inconclusive, the Department of Defense (DOD) flew the Cosmic Ray Upset Experiment again. This payload, first flown on STS-8, contained a device sensitive to cosmic rays. Thereby, experimenters could establish a good baseline reference of the probability and incidence of cosmic rays inducing errors in microcircuits.

PAYLOAD: G349
CUSTOMER: Goddard Space Flight Center; Noel W. Hinners

To expand knowledge of the little understood phenomenon of atomic oxygen erosion, Goddard Space Flight Center experimenters flew the atomic oxygen Contamination Monitor Package (CMP) a second time. Whereas the CMP's first flight on STS-8 had been at an attitude and altitude which enhanced the effects of atomic oxygen, its flight on STS-41-B exposed it to a normal orbit where little atomic oxygen was expected. Experimenters then compared the corrosive effects from both altitudes.

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Preflight installation: GAS containers can be seen on both sides of the forward cargo bay. The round hatch in front of the installation crew is the airlock by which astronauts leave the cabin and enter the cargo bay during missions.

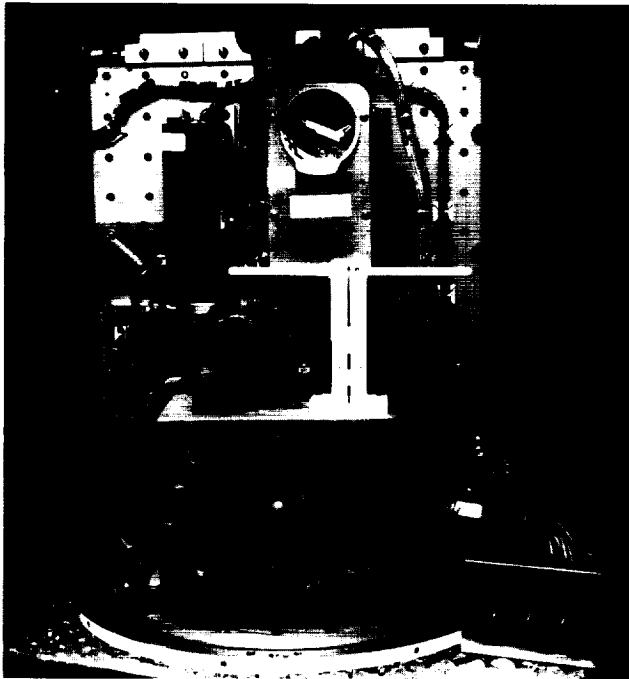
STS-41-G

Challenger, October 5, 1984

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AMONG THE EIGHT GAS PAYLOADS aboard STS-41-G was the first to attempt radio transmissions during a mission. The radio experiment, built by the Marshall Space Flight Center Amateur Radio Club (MARC), was to collect real-time data, temperature, and pressure readings from the other three experiments on G007. It would then convert the readings into voice signals and

transmit them to short-wave radio recipients, who would subsequently mail the data to MARC for analysis. Although a fascinating project, sending transmissions from a GAS payload during a Shuttle mission presented mission coordination difficulties. This prompted NASA not to accept other GAS payloads with transmitting requirements.



The "box" to the left of the t-shaped antenna is a Digi-talker, which turned G007's data into voice signals that were broadcast to radio hams around the world.

PAYLOAD: G007
CUSTOMER: Alabama Space and Rocket Center;
 Edward O. Buckbee

From this mission, the Project Explorer payload (G007) attempted to transmit radio-frequency measurements to ground-based radio hams around the world. The unique experiment was built by the Marshall Space Flight Center Amateur Radio Club (MARC). The other experiments in G007 were created by Alabama university students, guided by the Alabama-Mississippi section of the American Institute of Aeronautics and Astronautics and four major Alabama universities. These experiments investigated the growth of a complex inorganic compound with exceptional conductive properties (potassium tetracyanoplatinate); the solidification of an alloy with superplastic properties (lead-antimony); and the germination and growth of radish seeds in space. Unfortunately, the payload did not operate, but because the problem did not stem from a customer error, Project Explorer was awarded a reflight on STS-61-C.



(L to R) Gunter Schmitt and Christian Schmidt of Kayser-Threde and Neil Barthelme of Goddard Space Flight Center

PAYLOAD: G013
CUSTOMER: Kayser-Threde GMBH;
 Reiner Klett

Of basic interest to space endeavors, the HALEX payload tested the performance of halogen lamps. The lamps were to be the heat source for optical radiation furnaces planned for future material science processing in space. Up until the flight of this GAS payload, it was uncertain whether the lamps would perform as predicted during extended periods of microgravity. The flight, financed by the European Space Agency, was intended to verify the lamp's performance for more than 60 hours.

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A Nippon Electric Company engineer prepares G032.

PAYLOAD: G032
CUSTOMER: Asahi National Broadcasting Company, Ltd.

What happens when BB's are shot at free-standing spheres of water in microgravity? Would they be repelled by the water's surface tension? Would they burst the water ball? Knowing that surface tension holds water in a spherical shape in microgravity, the Asahi National Broadcasting Company designed an experiment to answer these questions. Their experiment generated water balls and then fired stainless steel BB's at them at varying speeds. In recording the impacts, they would learn more about the strength of surface tension in the absence of gravity.

In a different vein, a second experiment in their payload used five small electrical furnaces to produce new materials — a lead-zinc alloy, a glass composite (or ceramic) and crystals of an indium-antimony mixture.



Artist Joseph McShane assembles his experimental space sculpture.

PAYLOAD: G038
CUSTOMER: Marshall-McShane;
 Joseph W. McShane

Space Art: Artists who want to use GAS payloads for aesthetic purposes first must satisfy the program's scientific experimental requirements. Through his unique payload, artist Joseph McShane did both — performing valuable research while realizing his desire to capture the essence of space for those who are earth-bound. McShane used vacuum deposition techniques to coat eight glass spheres with gold, platinum, and other metals to create lustrous space sculptures. His deposition process was similar to that used on Earth to coat lenses, glass, and mirrors, but

the vacuum and weightlessness of space allowed a highly uniform coating that was just a few microns thick.

A ninth control sphere was evacuated to the natural vacuum level of space and sealed. Once back on Earth, McShane could take measurements from it to determine the vacuum level at which the other depositions had occurred. This sphere — rather, the “pure space” within it — was particularly meaningful to McShane, for it allowed individuals to contemplate space firsthand.



(L to R) Technician Chris Noll and project manager George Orton prepare their payload for a vibration test.

PAYLOAD: G074
CUSTOMER: McDonnell Douglas Astronautics Company;
 Henry E. Duehlmeirer

Creating a more versatile, inexpensive way of supplying fuel to spacecraft engines was the goal of this McDonnell Douglas payload. Its experiments demonstrated two methods of delivering partially full tanks of liquid fuel, free of gas bubbles, to engines that control and direct orbiting spacecraft. These zero-gravity fuel system tests were particularly concerned with studying the fluid dynamics of liquid fuels in tanks during the course of the mission.

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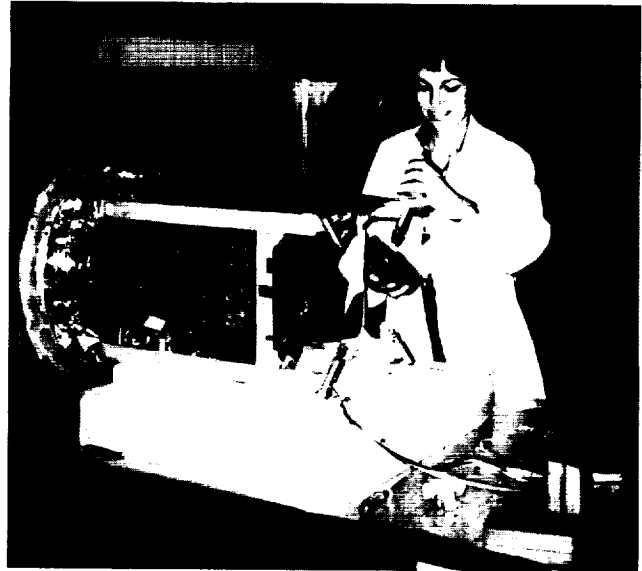
PAYLOAD: G306

CUSTOMER: Department of Defense Space Test Program;
Colonel Richard B. Kehl

Skylab Missions in 1973 and 1974 observed an unexpectedly large flux of heavy ions (electrically charged ions of oxygen and heavier atomic elements) capable of upsetting the microelectronic circuits on satellites. Payload

G306, the Trapped Ions in Space (TRIS) experiment, recorded the tiny radiation damage tracks left by such ions as they passed through a stack of track-detecting plastic sheets during flight. Upon return to Earth, the tracks were etched chemically, revealing cone-shaped pits where particles had passed. Investigators then studied the pits to deduce the energies and arrival directions of the different types of ions collected by TRIS. Sponsored by the U.S. Air

Force, TRIS was a joint project of the Cosmic Ray Astrophysics Group at the Naval Research Laboratory and the U.S. Naval Academy's Sigma Pi Sigma Physics Honors Society.



Lorraine Beahm of the Naval Research Laboratory prepares the Trapped Ions in Space payload.

PAYLOAD: G469

CUSTOMER: Goddard Space Flight Center;
Noel W. Hinnners

CRUX III evolved from the earlier Cosmic Ray Upset Experiments flown on STS-8 and STS-41-B. A cooperative effort by IBM Corporation and Goddard Space Flight Center, CRUX III tested four different types of advanced, state-of-the-art microcircuits, totaling over 12 megabits.

These devices were expected to be more sensitive to cosmic ray upset than those flown previously. Additionally, STS-41-G's angle of inclination provided for measurements at high latitudes where the cosmic ray spectrum is not shielded by Earth's magnetosphere. Thus, the cosmic ray environment was harsher by orders of magnitude than it had been for the previous CRUX payloads carried at lower latitudes.



USU student Scott Thomas readies his thermocapillary experiment.

PAYLOAD: G518

CUSTOMER: Utah State University;
Bartell C. Jensen

The ability to refly GAS experiments within a short turnaround period was demonstrated by Utah State University (USU) students on their G518 payload. Four USU experiments flown as two different payloads on STS-41-B were reconfigured into this single payload, which flew just four months later on STS-41-G. The brief time between their flights might be one of the fastest turnarounds for space experiments in NASA history; it certainly was for any university program associated with the Shuttle. The experiments explored several basic physical processes in microgravity: capillary waves caused when water is excited; separation of flux and solder; thermocapillary convection; and a fluid flow system in a heat pipe experiment.

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STS-51-D

Discovery, April 12, 1985

ON TUESDAY, March 12, 1985, Johnson Space Center and NASA Headquarters personnel decided that four GAS payloads could be added to the Shuttle's April flight — if the payloads could be ready for installation by the upcoming weekend. GAS team members made a telephone canvass of experimenters with flight-ready payloads and found only two customer organizations that could prepare their payloads by the deadline.

One of these payloads, G471, was an experiment at Goddard Space Flight Center in Maryland and had to be shipped by truck to Kennedy Space Center in Florida. The other payload, G035, was from the Asahi National Broadcasting Co. of Tokyo. Fortunately, this payload had already arrived at Kennedy in preparation for an upcoming flight; however, the payload manager and engineers were still in Japan. After their initial Tuesday phone discussion, the payload manager and two engineers from the customer's contractor, the Nippon Electric Company, boarded a jet. They arrived at Kennedy Thursday evening to start preflight preparations. By Saturday, G035 was installed in the Discovery. Without a doubt, the customers and GAS team had integrated their payloads in the shortest time possible.



The Capillary Pumped Loop Experiment demonstrated a new way to transfer waste heat away from the orbiter and into space.

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Metal BB's hitting water spheres in space gave G035's researchers more knowledge about surface tension of water in microgravity.

PAYLOAD: G035
CUSTOMER: Asahi National Broadcasting Co. Ltd.

On the first flight of the Asahi National Broadcasting Company's payload (G032 on STS-41-G) the materials processing experiments went smoothly, but the water in the Water Ball Collision experiment froze. The company arranged a reflight, G035, adding more heaters to the second payload. This time, spheres of water formed as planned. BB's were fired into the spheres at varying speeds to learn if they could overcome the surface tension. Video cameras recorded the fascinating collisions, yielding new insight on the force of surface tension in microgravity. The success of this payload's second flight clearly demonstrated the value of being able to retrieve, evaluate, modify, and reflly experimental payloads flown aboard Shuttle missions.

PAYLOAD: G471
CUSTOMER: Goddard Space Flight Center;
Noel W. Hinners

Based on a natural process: the same principal by which plants transport water from their roots to their leaves was used in designing the Capillary Pumped Loop experiment. The purpose of this Goddard payload was to demonstrate that a capillary pumped system could transfer waste heat from a spacecraft out into space. The two pumps in the system, built by the OAO Corporation, had no moving parts. Instead, each pump contained a wick of porous material saturated with fluid. When heat was added to the fluid, it evaporated, producing a pressure gradient or pumping action that circulated the fluid (the same action by which water ascends plant stems.) The fluid travelled — transporting the heat — to a condenser. This entire system, mounted on a condenser plate, was attached to a special GAS container top plate designed by the experimenters; through this the heat radiated into space.

STS-51-B

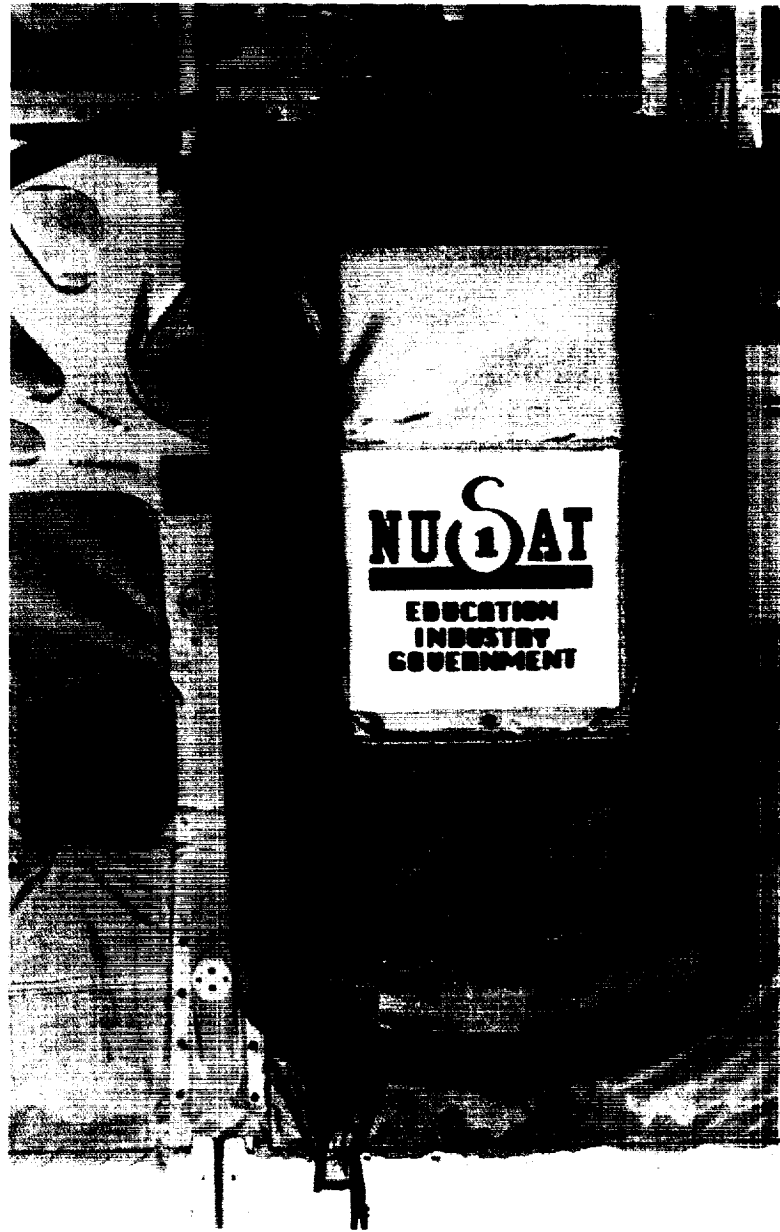
Challenger, April 29, 1985

A NEW ERA commenced for the GAS program with the launch of STS-51-B. Onboard were the first two satellites to be ejected from a GAS container — G010, the Northern Utah Satellite (NUSAT), and G308, the Global Low Orbiting Message Relay (GLOMR). The pioneering energy behind this new capability came from the Utah State University Get Away Special community. Repeatedly, since their earliest discussions with NASA, they had asked the agency to consider launching small satellites from GAS containers. From these ongoing discussions it became apparent that if the demands on the orbiter and crew could be held to a minimum, useful satellites could be ejected from GAS containers.

A cooperative development effort with the NUSAT team began. The NUSAT group contributed the design and fabrication of the satellite support pedestal and ejection spring system, adapting a proven Delta Rocket release mechanism to suit GAS satellite release requirements. They carried this work out under regular NASA review. Meanwhile, the GAS team developed the interface electronics necessary to support GAS satellite ejection. The GAS team also modified the existing motorized door assembly to create the Full Diameter Motorized Door Assembly which would allow a satellite to exit through the full diameter of the GAS payload container. As a result of these combined efforts, the deployment of satellites became an optional service for future GAS customers.



Hal Merritt, a Globesat engineer with the NUSAT team, checks the satellite's solar cells.



The first satellites ejected from GAS containers — the Northern Utah (NUSAT) and Global Low Orbiting Message Relay (GLOMR) — took to space on STS-51-B.

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(L to R) Joe Ducosin, GAS team manager, shows NASA astronauts Norman E. Thagard and Col. Frederick

PAYLOAD: G010
CUSTOMER: R. Gilbert Moore

The pioneer GAS satellite sprang into a twenty-month orbit from this payload. The brain-child of a Federal Aviation Administration (FAA) engineer, the Northern Utah Satellite (NUSAT) was built as a Weber State College senior class project. Its purpose was to provide a safer and more efficient means for the FAA to calibrate airport radar equipment. The college students assembled NUSAT with components and technical backup from an all-volunteer team from Utah State University, New Mexico State University, the FAA, Goddard Space Flight Center, the U.S. Air Force, and more than 26 private corporations. Because NUSAT was the first-of-a-kind, as well as an example of extraordinary cooperation between education, industry, and government, the NUSAT structural test prototype became part of the Smithsonian Institution's permanent collection in October 1987.

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PAYLOAD: G308
CUSTOMER: Department of Defense Space Test Program;
 Colonel William F. Fratzke

Working like an electronic mail system: the Global Low Orbiting Message Relay (GLOMR) satellite was planned to pick up digital data streams from ground users, store the data, and deliver the messages in these data streams to customers' computer terminals upon command. Built by Defense Systems, Inc. of McLean, Virginia, GLOMR was designed to remain in orbit about one year. Unfortunately, because of a malfunction in the Motorized Door Assembly, GLOMR was not deployed on this mission.

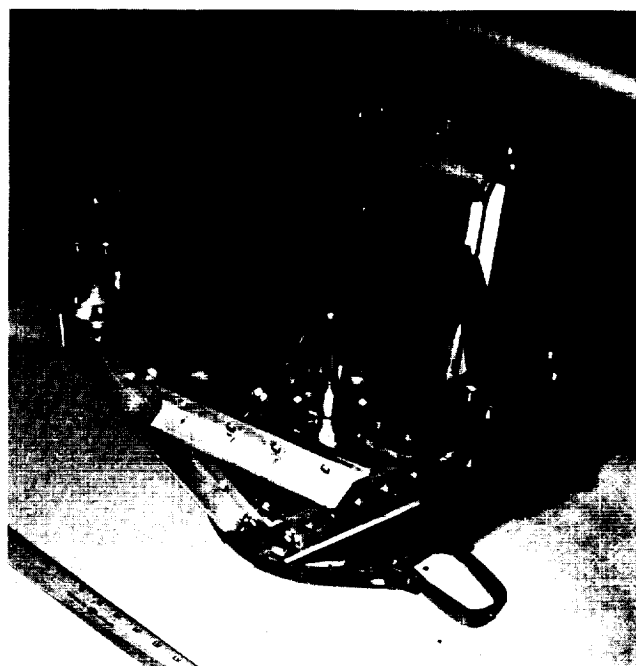


Satellite (NUSAT) and the Global Low Orbiting Message Relay

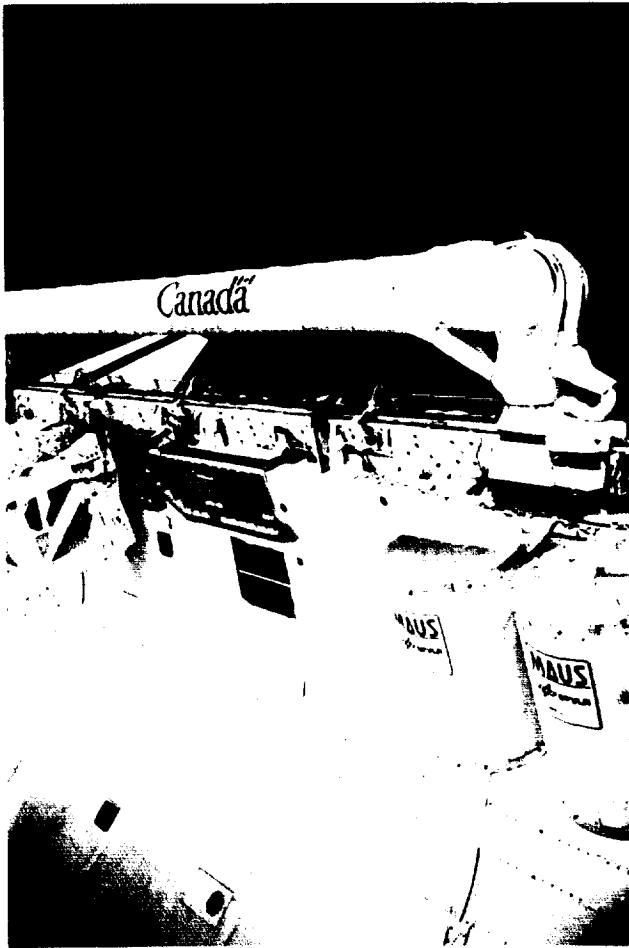


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D. Gregory the spring pedestal that will eject GAS satellites from their mission.



This ejection mechanism would lift NUSAT into an independent orbit.

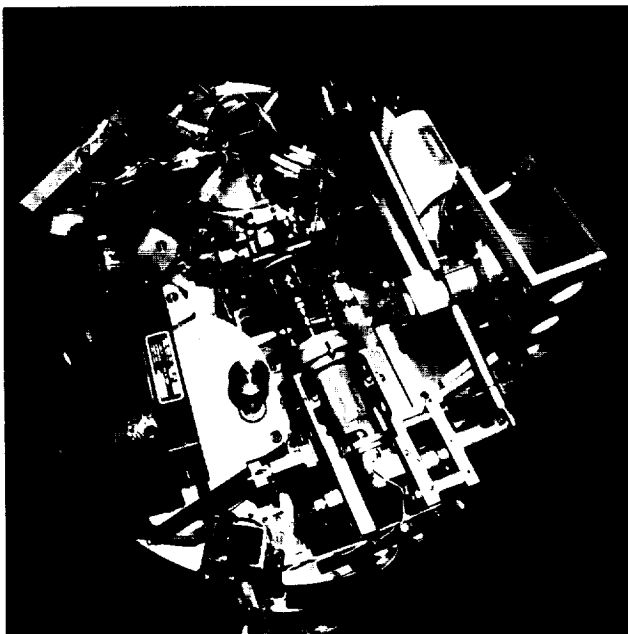


STS-51-G

Discovery, June 17, 1985

THE GAS PROGRAM CONTINUED ITS BUSIEST YEAR, as six more GAS payloads took to space on the Discovery. Three of the payloads were from West German customers, one (G025) from the ERNO-Raumfahrttechnik firm, the other two (G027 and G028) from the Federal Republic of Germany's material science program, Project MAUS. The project MAUS payloads were the first to use the GAS Program's dual payload option. This option was added to better accommodate customers with numerous GAS payloads. According to the GAS program's original policy, a customer could fly one payload every eleven missions. This policy cost some users — especially those who had to travel long distances — excessive travel and time away from work. Consequently, the GAS program adopted the dual payload option, which allowed users to fly two payloads on one Shuttle flight every 20 missions.

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This Liquid Sloshing Experiment provided information for managing propellants in surface tension tanks.

PAYLOAD: G025
CUSTOMER: ERNO-Raumfahrttechnik GMBH;
H. Hoffman & P. Sandermeier

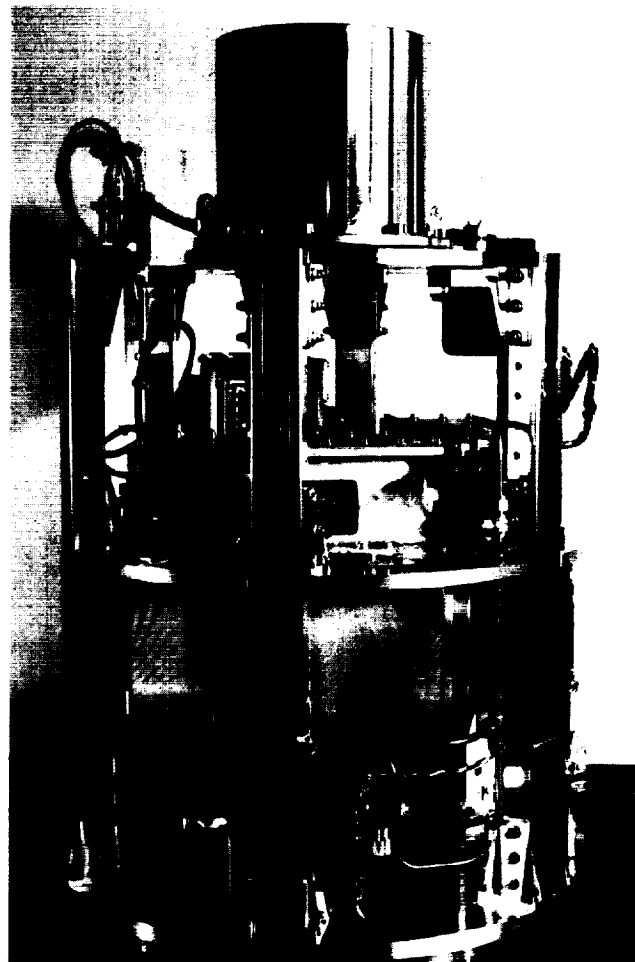
The development of future spacecraft fuel tanks was advanced in payload G025, which examined the behavior of liquid in a tank in microgravity. This Liquid Sloshing experiment simulated the behavior of liquid propellants in satellite tanks during in-orbit operations. The experiment subjected a reference fluid in a hemispherical model tank to linear acceleration inputs of known levels and frequencies. The experiment results were expected to validate and refine characteristics of tank-fluid systems and to be especially useful in the design of devices that manage propellants in surface tension tanks. The experiment was designed and built by the European firm, MBB/ERNO, Bremen, West Germany.

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PAYLOAD: G027
CUSTOMER: DFVLR;
H. Schreiber & H. Hebenstrick

Ceramic technology research involving slipcasting under microgravity was performed in payload G027 by Germany's materials research project MAUS. On Earth, the process of using ceramic slurry (a watery clay mixture) to form complex shapes of hollow bodies has limited applications. Gravitational influences, such as sedimentation of dispersed particles in the slurry, cause deformities. To avoid these, materials with equal densities or stabilizing additives must be used; both remedies have their limitations. Project MAUS scientists designed this experiment to demonstrate that slipcasting under microgravity is possible using a kneaded wax with dispersed particles of different density, diameter, and concentration.

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German scientists designed G027 to demonstrate the possibility of slipcasting under microgravity.

PAYLOAD: G028
CUSTOMER: DFVLR;
H. Schreiber & H. Hebenstrick

By melting and resolidifying a manganese-bismuth alloy in microgravity, the German Project MAUS experimenters anticipated an increase in the yield of compound formation. Manganese-bismuth forms by a peritectic reaction, one which transforms a mixture of two different phases (in this case, manganese — a solid — and bismuth — a liquid) into a single phase compound upon cooling. On Earth this reaction is incomplete, since the components exhibit different densities and become separated by sedimentation and buoyancy. The pure compound manganese-bismuth has promising applications as an inexpensive magnetic material because of its highly coercive strength.



An inexpensive magnetic material was expected to result from this German payload.



Mike Izquierdo, technical advisor to the El Paso students, connects their experiments to the flight controller. (Photo by Rudy Gutierrez, The El Paso Times)

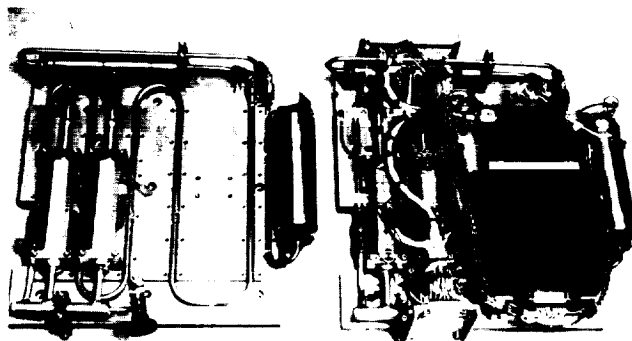
PAYLOAD: G034
CUSTOMER: Dickshire Coors; Richard N. Azar

El Paso area high school students designed and built the experiments in this GAS payload — an effort spanning nearly three years for the students and eight for their sponsors and advisors. Their microgravity experiments studied: the growth of lettuce seeds; barley seed germination; the growth of brine shrimp; germination of turnip seeds; the regeneration of the flat worm planeria; the wicking of fuels; the effectiveness of antibiotics on bacteria; the growth of soil mold; crystallization in zero gravity; the symbiotic growth of the unicellular algae chlorella and the milk product kefir; the operation of liquid lasers; and the effectiveness of Dynamic Random Access Memory computer chips without ozone protection.

PAYLOAD: G314
CUSTOMER: Department of Defense Space Test Program; Lt. Colonel Joseph S. Kuzniar

Originally flown on STS-7, the Space Ultraviolet Radiation Environment (SURE) instruments once again gathered data on radiation in the upper atmosphere. SURE consisted of a spectrometer which separated the extreme ultraviolet wavelength band into two intervals of 128 discrete wavelengths. By observing and recording the radiation at distinct wavelengths, SURE obtained signatures (characteristics) of atmospheric and ionospheric atoms, molecules, and ions. These measurements provided a means of remotely sensing the ionosphere and upper atmosphere.

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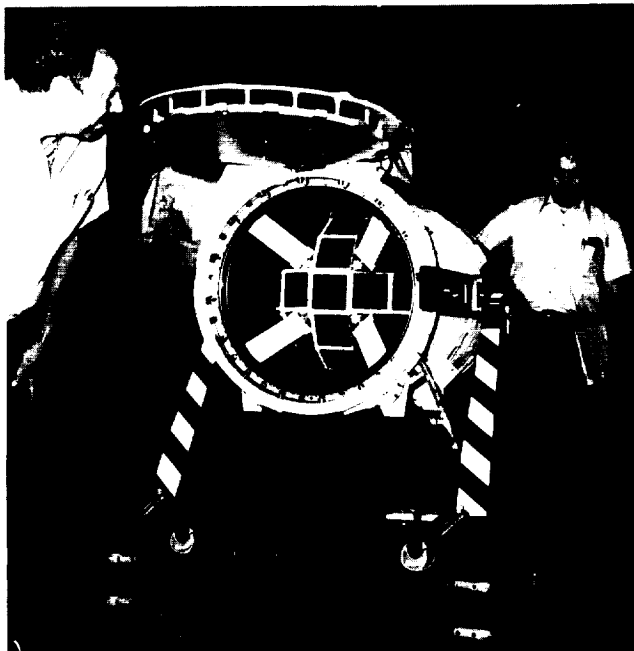
Capillary Pumped Loop Experiment: the condensation loop and fluid management system can be seen (left) before the electronics, heaters and sensors were integrated on the payload (right).

PAYLOAD: G471
CUSTOMER: Goddard Space Flight Center; Noel W. Hinners

When Goddard Space Flight Center experimenters opened the capillary pumped loop payload after its flight on STS-51-D, they found their payload had not been turned on. Because the problem stemmed from NASA interface electronics, the payload was awarded a reflight on this mission.



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(L to R) GAS team members Gary Walters and Jim O'Brien inspect the GLOMR satellite before its second flight.

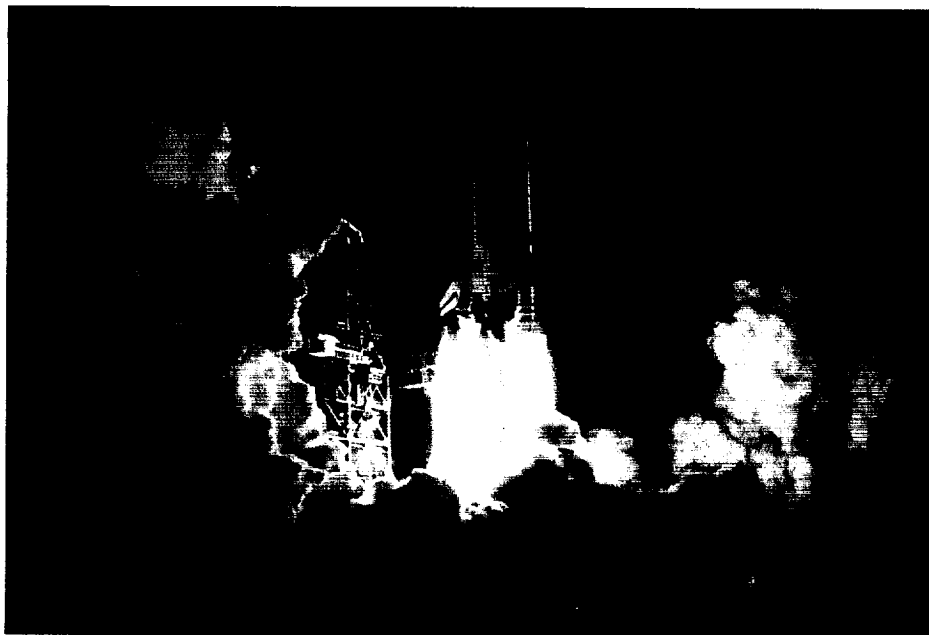
STS-61-A

Challenger, October 30, 1985

THE CHALLENGER'S ENTIRE CARGO BAY was chartered by the German Federal Ministry of Research and Technology (BMFT) for their "Deutschland Spacelab Mission D-1." But thanks to their courtesy, room was made in the Challenger for the reflight of the GLOMR satellite (G308).

PAYLOAD: G308
CUSTOMER: Department of Defense Test Program;
Colonel William F. Fratzke

On its first flight on STS-51-B, the Global Low Orbiting Message Relay (GLOMR) satellite was not deployed from its GAS container because a microswitch in the Motorized Door Assembly malfunctioned. After GLOMR returned to Earth, engineers evaluated the problem and developed an improvement for mounting and setting the switch. GLOMR was successfully deployed from G308 and remained in orbit for 14 months — longer than its designers had expected.



STS-61-B

Atlantis, November 26, 1986

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WITH ONLY ONE GAS PAYLOAD scheduled for STS-61-B, this mission required relatively little preparation by the GAS team. The timing was fortunate, since team members were already making arrangements for the January flight of STS-61-C, the most demanding mission of their first 10 years.



PAYLOAD: G479
CUSTOMER: Telesat Canada;
E.D. Thompson

***Towards a better mirror:** Telesat Canada, Canada's domestic satellite carrier, sponsored a nationwide contest for high school students to propose a GAS experiment. Students from the Ecole Secondaire Charlebois in Ottawa presented the idea of fabricating mirrors in space. They suggested that in using a vapor deposition technique in the microgravity environment of space, a more uniform distribution of a reflective coating on a glass substrate could be achieved than possible on Earth.*

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Students from Ecole Secondaire Chalebois prepare their "Toward a Better Mirror" payload.



The GAS bridge (foreground) being lowered for installation into the payload canister, a transport container the size of the Shuttle bay.

Holding a dozen payloads, the GAS bridge saved valuable installation time inside STS-61-C.

STS-61-C

Columbia, January 12, 1986

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COLOR PHOTOGRAPH

STS-61-C PROVIDED A GRAND FINALE for the first decade of the GAS Program. Aboard the Columbia were thirteen GAS payloads — the most allotted to one mission — and the new GAS bridge, a structure that spans the payload bay and can carry a dozen GAS containers.

Neither these payloads nor the bridge were originally scheduled for STS-61-C, but about five months before launch NASA officials realized that one of the mission's major payloads might not be ready in time. This would leave a large amount of unused space in the orbiter — creating an opportunity for a different payload or payloads. The GAS team was notified that the GAS bridge and an additional GAS payload could possibly fly on the Columbia. Before the openings were firm, the team needed to ask their customers if they wanted the flight opportunities. In doing so, they warned the customers that even after they performed preflight preparations at Kennedy, their payloads could not fly if the major one were finished in time. All the contacted customers decided that a possible flight was worth the risk.

By October, as preflight preparations of the GAS payloads at Kennedy neared completion, the GAS team and customers learned their gamble had paid off. They would indeed fly on STS-61-C.

The next step was installing the thirteen payloads in the Columbia. According to customary procedures, one was sent to Kennedy's Orbiter Processing Facility for installa-

tion. But to cut costly work-time inside the orbiter, the other twelve would be installed on the bridge before going to the orbiter. Since the bridge was too big for the GAS preparation facility, the twelve payloads were trucked to a different building. There they were mounted on the bridge and each individually connected to the bridge electrical harness. Once installed in the orbiter, a single connection from this harness would connect all the payloads to the GAS control wiring in the cargo bay.

Next, a truck moved the bridge to the Operations and Changeout Building for installation in a weather-proof canister the size of the orbiter bay. Once loaded with the bridge and the major payloads, the canister was moved to the launch pad and placed inside the payload changeout room in the tower next to the orbiter. This "clean-room" rotated around until its doors mated with the orbiter's bay doors. The bridge and payloads were then transferred to the Columbia without danger of dust or dirt contamination.

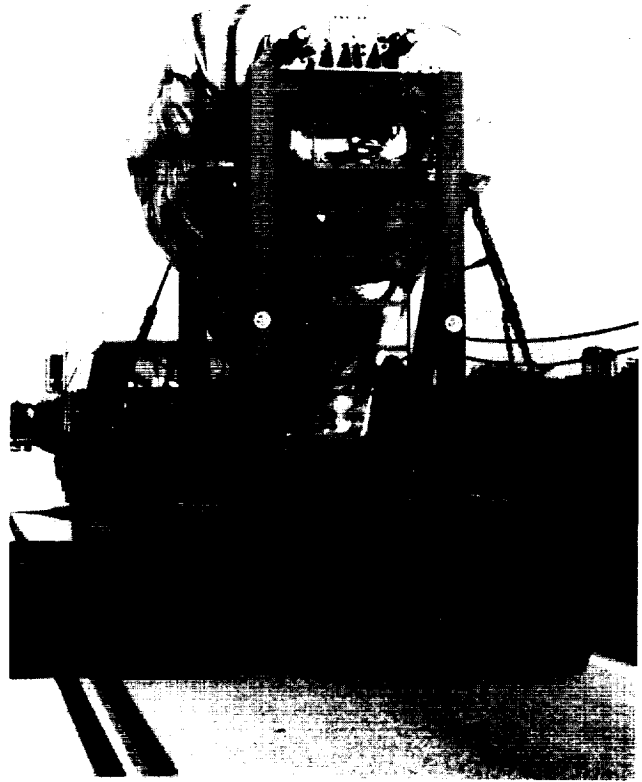
Aside from the new procedures concerning the bridge, the mission held a number of other notable events: the only radio transmissions of GAS experiment data were made; three GAS containers were electrically interconnected side-by-side as a single payload; three payloads with Motorized Door Assemblies were flown; and an Environmental Monitoring Package measured the effect of the launch and landing environment on the bridge.

The Environmental Measurement Payload

To understand the physical forces which work on the GAS bridge during a Shuttle mission, the GAS team conceived the Environmental Measurement Payload (EMP). Designed and built by Goddard's Special Payloads Division, the EMP measured the effects of launch and landing forces on the bridge, and, hence, on the internal environment of the GAS containers. Sound levels, vibrations, and temperature were measured by attaching acoustical pickups, accelerometers, strain gauges, and thermocouples to the bridge. These instruments were connected to a GAS container with equipment that controlled the instruments and recorded their data.

PAYLOAD: G007
CUSTOMER: Alabama Space and Rocket Center;
Edward O. Buckbee

New Capabilities resulted from an initial setback: when G007 flew on STS-41-G, it was not turned on. Postflight investigation determined the experimenters were not at fault, and they were awarded this reflight. Taking advantage of the experience gained from their first flight, the experimenters refined their original payload for this mission. They installed a Solid Rocket Booster battery more powerful than the type previously used. This made it possible to add a new oven to the alloy solidification experiment and heaters to the radish seed experiment. The timeline of the crystal growth chamber changed from 24 hours to full mission duration. The radio transmissions experiment increased its output from 0.5 to 5.0 watts, and transmissions occurred at the start of each minute instead of every four minutes. With these improvements, the experiments and radio transmissions on G007's second flight yielded excellent data.



The GAS bridge is trucked across Kennedy Space Center for installation in the orbiter canister along with the major payloads.

PAYLOAD: G062
CUSTOMER: General Electric Co. Space Division;
Bob Birman

G062 not only provided Penn State engineering students with first-hand experience in spacecraft testing; it also provided data on critical problems facing aerospace industries. Fuel slosh, which causes a disturbance in the spin axis of satellites, was one of the problems investigated on the payload. In another experiment, liquid droplets were formed and shattered, yielding the liquid's surface tension. Comparing this data with that collected on Earth, students could determine the effect of gravity on surface tension and help quantify surface tension formulae. A third experiment was designed to determine how convection contributes to heat transfer by comparing two identical experiments, one performed in space, the other on Earth. G062 was donated to Penn State University by General Electric's Space Division.



Penn State students Troy Taylor (left) and Dave Moul assemble G062.

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PAYLOAD: G310
CUSTOMER: Department of Defense Space Test Program;
Colonel William F. Fratzke

How would vibrating metal react in microgravity? Would the lack of atmospheric pressure in space make vibrations last longer or be stronger than on Earth? These types of questions — relevant to designers and builders of solar arrays and other spacecraft structures — were studied in the U.S. Air Force Academy's Flexible Beam Experiment (FLEXBEAM). To carry out this research, an aluminum beam, fixed at one end and free at the other, was struck with a hammer driven by a rotary solenoid. Five strain gauges measured vibrations. A damping solenoid at the beam's free end then brought the vibrations under control. The damping characteristics were recorded for comparison with those from an Earth-bound control experiment.



FLEXBEAM measured microgravity's impact on vibrating metal.

PAYLOAD: G332
CUSTOMER: Booker T. Washington High School;
F.D. Wesley

*Students from Houston's Booker T. Washington High School and the High School for Engineering Professions shared payload G332 to conduct research in the areas of the life sciences and fluid physics. Washington High students flew the brine shrimp *Artemia* to determine the behavioral and physiological effects of microgravity on cysts hatched in space. Students from the engineering high school examined the thermal conductivity and bubble velocity of air and water, substances which separate when combined on earth due to differences in their densities.*



Booker T. Washington High School students receive a proclamation for their GAS payload from Houston Mayor Kathy Whitmire and City Councilman Dale Gorczynski (behind mayor).

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PAYLOAD: G446
CUSTOMER: Alltech Associates, Inc.;
Brent R. Erwin

Fields as varied as medicine, law enforcement, and petroleum processing could benefit from the results from G446. Designed by Alltech Associates, Inc. of Waukegan, Illinois, this experiment manufactured High Performance Liquid Chromatography Analytical Columns in microgravity. Used for chemical analysis, the columns allow the separation of a chemical mixture into its components, so the chemicals can be quantified. When manufactured on Earth, the columns are not as efficient as theoretically possible, because the minute particles with which they are packed do not settle uniformly. The experiment's designers expected that by reducing gravity, a more efficient column could be produced.



Alltech Associates expected G446 to prove that a microgravity environment could benefit chemical analysis work.



Sister Julie Hanser, President of St. Mary's Hospital, and Mike Muckerheide, payload manager, report on G449's results at a postflight press conference.

PAYLOAD: G449
CUSTOMER: St. Mary's Hospital, Milwaukee

PROJECT JULIE (Joint Utilization of Laser Integrated Experiments) marked two firsts for the GAS program: it was the first payload flown by a private hospital and later became the first to be displayed at the National Air and Space Museum. Project Julie was built by Saint Mary's Hospital of Milwaukee, Wisconsin, which had solicited the payload's 20 medical and laser experiments from researchers throughout the nation.



President Reagan examines GAS hardware with James Beggs (l), NASA Administrator, and Dr. Vincent Salomonson (r), Chief, Goddard's Laboratory for Terrestrial Physics, during a Goddard visit.

PAYLOADS: G462, 463, & 464
CUSTOMER: NASA Office of Space Science and Applications; Burton I. Edelson

An ambitious viewing agenda was planned for this three-container payload. The two ultraviolet spectrometers in this Ultraviolet Cosmic Background Experiment (UVX) were to look into distant space to observe the high energy spectrum thought to be associated with the origin of the universe. Other observational targets included galaxies, dust areas, the Comet Halley, and selected stars.

The experiment's design was as unique as its function: it was the only set of GAS experiments to fly as a group of three electrically interconnected containers. It consisted of the Feldman Spectrophotometer from Johns Hopkins University (in container G463); the Bowyer UV Spectrometer from the University of California, Berkeley (in container G464); and the GSFC support avionics system (payload G462). Finding an opportunity to fly these three GAS containers side-by-side was so difficult that the UVX experiment will retain the distinction of being the only experiment to use three or more interconnected GAS containers.

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PAYLOAD: G470
CUSTOMER: Goddard Space Flight Center;
Noel W. Hinners

The moth in space project was developed by the U.S. Department of Agriculture (USDA) and the Goddard Space Flight Center to learn if weightlessness could be a key to halting the devastation caused by gypsy moths. These pests have been responsible for defoliating millions of acres of trees in the United States. USDA scientists hoped to increase their ability to raise sterile male moths, which would then be mated with females to produce sterile offspring. If weightlessness were found to reduce the insect's hibernation period, sterile males could be bred more quickly, and the defoliation brought under control.



The thermograph in the center of the gypsy moth experiment recorded temperature over long periods of time.

PAYLOAD: G481
CUSTOMER: Vertical Horizons;
Howard Wishnow

Aside from survival, people living in space will have many needs, among them, the aesthetic. Artist Ellery Kurtz and environmental psychologist Howard Wishnow founded Vertical Horizons, a company dedicated to the enhancement of life in space. Their GAS payload transported samples of painted linen canvases and other artistic materials into space. They evaluated the materials postflight to learn how the space environment had affected them. The experiment formed a foundation for the future study of methods for transporting visual art objects in space.

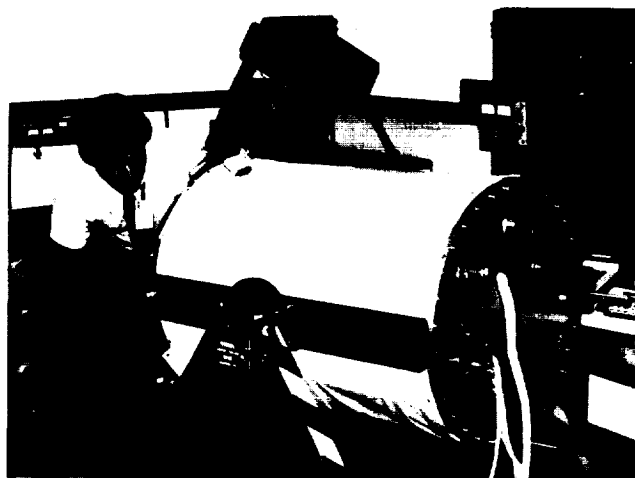


(L to R) Ellery Kurtz and Howard Wishnow discuss the pigments used in the artwork experiments in G481.

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PAYLOAD: G494
CUSTOMER: National Research Council of Canada;
R.D. Hendry

PHOTONS (Photometric Thermospheric Oxygen Nightglow Study) was designed to study oxygen chemistry in the Earth's thermosphere, as well as the "shuttle glow" caused by the chemical reaction between Shuttle emissions and the space environment. In the thermosphere, the region between 80 and 500 kilometers (50 and 300 miles) above the Earth, the atmosphere changes from a molecular to an atomic nature. Currently, little is known about the thermosphere. With more information, better models can be made to predict both natural and human-related changes in this region. The second aspect of PHOTONS' study provided information on how light contamination or "shuttle glow" affects measurements made by telescopes, interferometers, and other instruments carried on the Shuttle. To carry out its two-fold research, PHOTONS used seven photometers built at the Herzberg Institute of Astrophysics of the National Research Council of Canada.



Studying shuttle glow was one of G494's goals. Frank Harris, National Research Council of Canada, checks the payload.

Following is a list of the 53 GAS payloads flown on STS-4 through STS-61-C. Payload Numbers were assigned as reservations were purchased. The Payload Manager (Mgr) was the customer's representative responsible for building the payload. The NASA Technical Manager (Tech Mgr) was the NASA employee who handled communications between the customer and GAS team.

PAYLOAD: G001
 CUSTOMER: R. Gilbert Moore
 PAYLOAD MGR: David W. Yoel
 NASA TECH MGR: Ernest Busboso

PAYLOAD: G026
 CUSTOMER: DFLVR, German Aerospace Research Est.
 H. Schreiber, H. Hebenstrick
 PAYLOAD MGR: Dieter Baum
 NASA TECH MGR: Leroy F. Shillet

PAYLOAD: G005
 CUSTOMER: The Asahi Shimbun
 Shigeru Kimura
 PAYLOAD MGR: Shigeru Kimura
 NASA TECH MGR: Lawrence R. Thomas

PAYLOAD: G049
 CUSTOMER: U.S. Air Force Academy
 General Robert E. Kelley
 PAYLOAD MGR: Major John E. Hatelid
 NASA TECH MGR: Joseph Ducosin

PAYLOAD: G381
 CUSTOMER: George W. Park Seed Co.
 George B. Park, Jr.
 PAYLOAD MGR: Dr. James A. Alston
 NASA TECH MGR: Herbert E. Foster

PAYLOAD: G002
 CUSTOMER: Kayser-Threde GMBH,
 Reiner Klett
 PAYLOAD MGR: Gunter Schmitt
 NASA TECH MGR: Albert D. Blunt

PAYLOAD: G009
 CUSTOMER: Purdue University
 PAYLOAD MGR: Dr. John T. Snow
 NASA TECH MGR: Richard Palace

PAYLOAD: G012
 CUSTOMER: RCA
 David Shore
 PAYLOAD MGR: Joseph Carbone
 NASA TECH MGR: Gary W. Cooper

PAYLOAD: G033
 CUSTOMER: Steven Spielberg
 PAYLOAD MGR: Kirk R. Haselton
 NASA TECH MGR: Lawrence R. Thomas

PAYLOAD: G088
 CUSTOMER: Edsyn, Inc.
 William S. Fortune
 PAYLOAD MGR: Wayne A. Murray
 NASA TECH MGR: Bernard R. Karmilowicz

PAYLOAD: G305
 CUSTOMER: DOD Space Test Program
 Richard B. Kehl
 PAYLOAD MGR: Robert Conway
 NASA TECH MGR: Henry W. Albright

PAYLOAD: G345
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Robert Kreplin
 NASA TECH MGR: Paul Velgos

PAYLOAD: G346
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: John W. Adolphsen
 NASA TECH MGR: Norman E. Peterson

PAYLOAD: G347
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Robert Kreplin
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G348
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Roy McIntosh
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G475
 CUSTOMER: The Asahi Shimbun
 Shigeru Kimura
 PAYLOAD MGR: Shigeru Kimura
 NASA TECH MGR: Lawrence R. Thomas

PAYLOAD: G004
 CUSTOMER: Utah State University
 Dr. L. R. McGill
 PAYLOAD MGR: Dr. L. R. McGill
 NASA TECH MGR: Ernest Busboso

PAYLOAD: G008
 CUSTOMER: Utah State University
 Dr. L. R. McGill
 PAYLOAD MGR: Dr. L. R. McGill
 NASA TECH MGR: Ernest Busboso

PAYLOAD: G051
 CUSTOMER: GTE Laboratories, Inc.
 PAYLOAD MGR: Alfred Bellows
 NASA TECH MGR: Richard J. Palace

PAYLOAD: G309
 CUSTOMER: DOD Space Test Program
 Colonel John T. Viola
 PAYLOAD MGR: John W. Adolphson
 NASA TECH MGR: Norman E. Peterson, Jr.

PAYLOAD: G349
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Roy McIntosh
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G007
 CUSTOMER: Alabama Space and Rocket Center
 Edward O. Buckbee
 PAYLOAD MGR: Konrad K. Dannenberg
 NASA TECH MGR: Jack J. Gottleib

PAYLOAD: G013
 CUSTOMER: Kayser-Threde GMBH
 Reiner Klett
 PAYLOAD MGR: Gunter Schmitt
 NASA TECH MGR: Neal Barthelme

PAYLOAD: G032
 CUSTOMER: Asahi National Broadcasting Company
 PAYLOAD MGR: Kuzuo Fujimoto
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G038
 CUSTOMER: Marshall-McShane
 Joseph W. McShane
 PAYLOAD MGR: Joseph W. McShane
 NASA TECH MGR: Timothy Premack

PAYLOAD: G074
 CUSTOMER: McDonnell Douglas Astronautics Company
 Henry E. Duehlmeier
 PAYLOAD MGR: George F. Orton
 NASA TECH MGR: Alan Lindenmoyer

PAYLOAD: G306
 CUSTOMER: DOD Space Test Program
 Colonel Richard B. Kehl
 PAYLOAD MGR: Dr. James Adams
 NASA TECH MGR: Richard J. Palace

PAYLOAD: G469
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Norman E. Peterson
 NASA TECH MGR: Norman E. Peterson

PAYLOAD: G518
 CUSTOMER: Utah State University
 Bartell C. Jensen
 PAYLOAD MGR: Dr. L. R. Megill
 NASA TECH MGR: Alan Lindenmoyer

STS-51-D, April 12, 1985, 2 Payloads

PAYLOAD: G035
 CUSTOMER: Asahi National Broadcasting Co.
 PAYLOAD MGR: Kazuo Fujimoto
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G471
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Roy McIntosh
 NASA TECH MGR: Gerard Durbach

STS-51-B, April 29 1985, 2 Payloads

PAYLOAD: G010
 CUSTOMER: R. Gilbert Moore
 PAYLOAD MGR: Dr. L. R. Megill
 NASA TECH MGR: Lawrence L. Thomas

PAYLOAD: G308
 CUSTOMER: DOD Space Test Program
 Colonel William F. Fratzke
 PAYLOAD MGR: Dr. George Sebestyen
 NASA TECH MGR: Lawrence Thomas

STS-51-G, June 17, 1985, 6 Payloads

PAYLOAD: G025
 CUSTOMER: ERNO-Raumfahrttechnik GMBH
 H. Hoffman & P. Sandermeier
 PAYLOAD MGR: Dr. Peter Vits
 NASA TECH MGR: Leroy F. Shiflett

PAYLOAD: G027
 CUSTOMER: DFVLR
 H. Schreiber & H. Hebenstrick
 PAYLOAD MGR: Dieter Baum
 NASA TECH MGR: Leroy F. Shiflett

PAYLOAD: G028
 CUSTOMER: DFVLR
 H. Schreiber & H. Hebenstrick
 PAYLOAD MGR: Dieter Baum
 NASA TECH MGR: Leroy F. Shiflett

PAYLOAD: G034
 CUSTOMER: Dickshire Coors
 Richard N. Azar
 PAYLOAD MGR: Suzanne S. Azar
 NASA TECH MGR: Lawrence Thomas

PAYLOAD: G314
 CUSTOMER: DOD Space Test Program
 Lt. Colonel Joseph S. Kuzniar
 PAYLOAD MGR: Robert Conway
 NASA TECH MGR: Henry W. Albright

PAYLOAD: G471
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Roy McIntosh
 NASA TECH MGR: Gerard Durbach

STS-61-A, October 30, 1985, 1 Payload

PAYLOAD: G308
 CUSTOMER: DOD Test Program
 Colonel William F. Fratzke
 PAYLOAD MGR: Dr. George Sebestyen
 NASA TECH MGR: Lawrence Thomas

STS-61-B, November 26, 1985, 1 Payload

PAYLOAD: G479
 CUSTOMER: Telsat Canada
 E. D. Thompson
 PAYLOAD MGR: Brian Butters
 NASA TECH MGR: Robert Demorest

STS-61-C, January 12, 1986, 12 Payloads

PAYLOAD: G007
 CUSTOMER: Alabama Space and Rocket Center
 Edward O. Buckbee
 PAYLOAD MGR: Konrad K. Dannenberg
 NASA TECH MGR: Jack O. Gottlieb

PAYLOAD: G062
 CUSTOMER: General Electric Space Division
 Bob Birman
 PAYLOAD MGR: Cathy Wolfgang
 NASA TECH MGR: Charles R. Lavery

PAYLOAD: G310
 CUSTOMER: DOD Space Test Program
 Colonel William F. Fratzke
 PAYLOAD MGR: Captain Christopher J. Worsowicz
 NASA TECH MGR: David W. Peters

PAYLOAD: G332
 CUSTOMER: Booker T. Washington High School
 F. D. Wesley
 PAYLOAD MGR: F. D. Wesley
 NASA TECH MGR: Phillip T. Smith

PAYLOAD: G446
 CUSTOMER: Alltech Associates, Inc.
 Brent R. Erwin
 PAYLOAD MGR: Brent R. Erwin
 NASA TECH MGR: Fred M. Witten

PAYLOAD: G449
 CUSTOMER: St. Mary's Hospital, Milwaukee
 PAYLOAD MGR: Myron C. Muckerheide
 NASA TECH MGR: Alan Lindenmoyer

PAYLOADS: G462, 463, & 464
 CUSTOMER: NASA Office of Space Science and Applications
 Burton I. Edelson
 PAYLOAD MGR: Theodore C. Goldsmith
 NASA TECH MGR: Norman E. Peterson

PAYLOAD: G470
 CUSTOMER: Goddard Space Flight Center
 Noel W. Hinners
 PAYLOAD MGR: Dora K. Hayes
 NASA TECH MGR: Mark D. Goans

PAYLOAD: G481
 CUSTOMER: Vertical Horizons
 Howard Wishnow
 PAYLOAD MGR: Howard Wishnow
 NASA TECH MGR: Richard Scott

PAYLOAD: G494
 CUSTOMER: National Research Council of Canada
 R.D. Hendry
 PAYLOAD MGR: C.R. Barrett
 NASA TECH MGR: Robert Demorest

Into the Next Decade

Today, ten years after its inception, the GAS Program has more than fulfilled its promise. Hundreds of people who, otherwise, could not have flown experiments in space have done so through the program.

As well, spin-offs from the program have been abundant. Many of the young scientists and engineers who executed GAS experiments as part of their educations are now working for NASA or within the aerospace industry. Universities have established space science curriculums around the availability of GAS payloads. Professional scientists and engineers throughout the world have made advances in research pertaining to medicine, materials processing, and space technology. GAS research options now include the deployment of GAS satellites.

As for the future, GAS payload flight opportunities are beginning to appear in proposed Shuttle manifests. As of June 1988, customers have reserved 495 payloads for future flights; of these, 93 have already submitted their payload requirements to NASA for review.

With these achievements behind us, the NASA GAS team and GAS experimenter community look with eagerness to the flight opportunities and challenges awaiting in the program's second decade.

Additional Information

For further information on GAS Program policies and reservation procedures contact:

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Code MCN
NASA Headquarters
Washington, D.C. 20546

For technical information pertaining to payloads contact:

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Goddard Space Flight Center
Greenbelt, Maryland 20771